A Trial Experiment On Studying Short-Term Water Quality Changes In Flooded Peat Soil Environments

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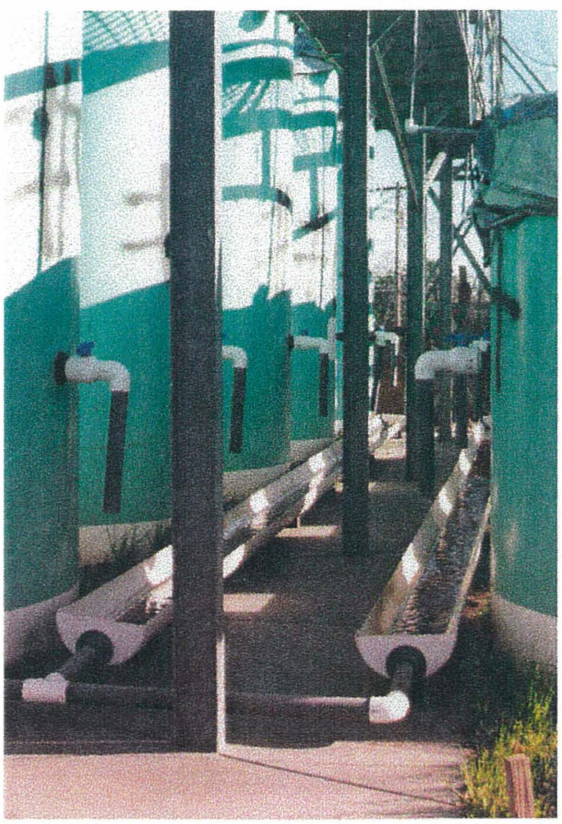
The peat soil was mixed by a backhoe prior to loading into the tanks.

The SMARTS facility began operating in mid-July 1998. This photo was taken when the second experiment began in January 1999. Plastic tarps were placed to prevent rainfall from entering the tanks and to limit evaporative losses and algal growth.



Troughs collected water drained from the standpipes in the tanks that had continuous water exchange. Local raccoons visited the troughs regularly at night searching for food as the SMARTS simulation of a Delta wetland fooled them.

Results

1. Experiment Adjustments

The new facility and experiment required some adjustments during the first half of the study. A chronology of these events and corrective actions were logged and their possible effects on the results are presented in the discussions of the data.

The odd numbered tanks were set to simulate stored water conditions with no additional water continuously added after initial filling. However, as the study proceeded into the hot summer, evaporation was high in some of these tanks. Water was added to top off these tanks and the amounts recorded. Tank 9 served as a test materials control to assess TOC from fiberglass and PVC materials used to run the experiment.

The even numbered tanks were set to simulate flooded conditions with a constant water exchange equal to one water volume exchange per week based on the water depth (inundation depth) of each tank. However, in the first half of the experiment, flow meters and tubing to the small tanks (2f and 4f) were sometimes clogged. Flows needed to be at approximately 110 ml/minute flow (equivalent to one water volume exchange of 294.5 gallons per week or 0.03 gallons per minute) in the two small tanks that had two feet of water. The very low flows were more attainable after the screw-type flow valves were obtained and installed on September 2.

Flows in the larger tanks (6f and 8f) with 7 feet of water were discovered to be 50 percent higher than the flow meter scale reading for 0.1 gpm. Therefore, flows were one-and-a-half exchanges (1616 gallons) per week during the 12-week run, not one exchange (1020 gallons) per week.

The combinations of the three factors (peat depth, water depth, and exchange rate) and two treatments (conditions) were assigned to each tank based on the standard design of experiment protocol.

Tank	Peat Soil Depth (ft.)	Water Depth (ft.)	Water Exchange volumes per week
1	1.5	2 (294.5 gal)	None
2f	1.5	2	1 vol/wk
3	4	2	None
4f	4	2	1 vol/wk
5	4	7 (1028 gal)	None
6f	1.5	7	1.5 vol/wk
7	1.5	7	None
8f	4	7	1.5 vol/wk
9	0	11 (1616 gal)	None

Note: Nominal rates, depths, heights, and volumes. Tank 9 served as materials test tank.

The tank pairs (no continuous water exchange vs. continuous water exchange) for comparison are:

1 vs. 2f ----shallow water (2') and peat (1.5') combinations
3 vs. 4f-----shallow water (2') and deeper peat depth (4') combinations
5 vs. 8f-----deep flooded (7') and deep peat soil depth (4') combinations
7 vs. 6f-----deep flooded (7') and shallow peat depth (1.5') combinations

Early startup problems after filling all tanks with water on July 2 caused a restart of the bank of small tanks. The bulkhead fitting for the stand-pipe in tank 3 broke when peat was loaded into the tank. It was not noticed until water was added to the tank. Although the tank was initially filled with water to a depth of two feet, the water depth was about two inches due to rapid absorption by the underlying four feet of peat soil on the following day. Peat soil has a porosity of about 80 percent. Consequently, only about two inches of water was emptied to replace the broken pipe fitting. After the repair, water was then added to refill to the two-foot water depth on July 8.

Tanks 1 and 2 were mistakenly overfilled to a water depth of four feet instead of two feet because of incorrect standpipe lengths placed in the tanks during construction of the SMARTS facility. Two feet of water was then drained from these two tanks on July 15. The standpipe to tank 4 also became displaced and required refilling of the tank with about two feet of water. A sediment sample from tank 4 was immediately collected for analysis to determine if there was a significant loss of organic carbon from the peat soil surface due to the water loss. If the emptying of water had any effect on the results, it would be lower concentrations of the measured constituents.

Due to the mishaps, the large tanks (5 – 9) were sampled first on July 15, 1998. The first sampling event for tanks 1- 4 was postponed to the following week on July 22, 1998. This postponement allowed the refilled tanks to be sampled one week after flooding the peat soil. Consequently, termination of the experiment ended one week earlier for tanks 5 - 9 than for tanks 1 - 4. Since each tank is totally independent of each other, the incidences that occurred had no impact on other tanks. The results can, therefore, be viewed as 9 independent experiments (9 tanks) conducted concurrently.

All tanks were sampled one week after filling the tanks with water. Original plans were to cover the tanks to eliminate algae growth and evaporation which could affect water quality (e.g., EC, TOC, DO, pH). Due to the lateness of the State Legislature in approving the Fiscal Year 1998 – 1999 budget, covers and misters were not procured in time before the start of the experiment. Not wishing to delay the startup past July, the decision was made to start and leave the tanks uncovered throughout this first trial experiment. Surface water samples in each tank were measured for chlorophyll *a* concentrations to assess the effects of algal growth on the water quality in the tanks.

The experiment terminated after 12 weeks (September 30, 1998 for tanks 5 - 9 and October 7, 1998 for tanks 1 - 4). All data are plotted in terms of weeks elapsed or submerged since startup (water filling of tanks). The dates of adding water to the no-water exchange tanks are shown below:

Date	Tank #	Volume (gal.)
August 12	7	61
August 19	7	61
September 2	1 7	49.5 23.1
September 23	3 7	60 54

The frequent additions of water to tank 7 were due to the combined effects of evaporation and possibly a slow leak although the leak could not be found. The approximate 54 – 61 gallons of water represented about 5 percent of the surface water volume (1028 gal.). The loss of water in tanks 1 and 3 were due to evaporation. Water was added to prevent exposure of the peat soil surface because the water levels began at 2 feet. The additional 50 – 60 gallons of added water was about 20 percent of the starting surface water volume of 295 gallons. The effects of dilution from the additional water on the water quality in these tanks are discussed in the following sections on peat soil water quality and surface water quality.

2. Water Supply and Materials Control Tank Water Quality

The water quality of the city water supply is shown in Table 3. TOC ranged from 1.2 mg/l to 1.8 mg/l and DOC 1.08 to 1.4 mg/l during the study. EC ranged from 131 to 158 µS/cm and alkalinity ranged from 38 to 49 mg/l. The bromide levels were below laboratory detection (0.01 mg/l). The TTHMFP test was not performed but based on current drinking water standards for THM (0.1 mg/l) and the initial materials water supply data, THM was about 0.08 mg/l. Residual chlorine was probably 2 mg/l, typical of water distribution systems.

Table 3. Water Supply Water Quality

Weeks Flooded	**0**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Date	**7/2**	**8/19**	**8/26**	**9/2**	**9/9**	**9/17**	**9/23**	**9/30**
TOC (mg/L)		1.5	1.6	1.8	1.3	1.6	1.6	1.2
DOC (mg/l)	1.08	1.3	1.3	1.4	1.2	1.3	1.2	1.1
UVA cm-1	0.014	0.016	0.018	0.019	0.017	0.021	0.021	0.018
Specific Absorb-ance		1.4	1.4	1.36	1.42	1.62	1.75	1.64
Alkalinity (mg/l as CaCO3)	38	44	47	52	48	59	44	47
Bromide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Field EC (µS/cm)			151	158	150	182	134	145
Field DO (mg/l)				5.9				
Field pH			6.65	6.7	6.5			

Relative to some water quality parameters observed in the Delta channels, the city tap water is much lower in organic carbon, TTHMFP, and EC. The low residual chorine dose in tap water is not high enough to form THMs. MWQI studies have shown that about 120 mg/l of chlorine is needed to maintain at least a 2 mg/l chlorine residual in the TTHMFP test for agricultural drain water collected from peat soil islands in the Delta (DWR, 1990). If the residual is not met, the formation of THMs is an incomplete reaction. It, therefore, was unlikely that the tap water supply contributed significantly to the observed TTHMFP, TOC, and DOC in the trial experiment.

Water quality in tank 9, the materials control tank, showed that leaching of organic carbon from the fiberglass tanks and PVC pipes were insignificant to affect the experimental results (Table 4). The water supply and tank 9 TOC and DOC concentrations were about the same (< 2 mg/l) during the first month before algal and bacterial growths in tank 9 affected water quality.

The increased TOC and DOC concentrations that were seen in tank 9 after four weeks were attributed to algae as shown by similar related trends in chlorophyll-*a*, pheophytin-*a*, TTHMFP, and computed particulate organic carbon (POC = TOC minus DOC) concentrations. Deposition of atmospheric dust probably added nutrients, substrate, and microorganisms to the tanks during the 12 weeks.

Table 4. Materials Control Tank Water Quality

Weeks	1	2	3	4	5	6	7	8	9	10	11	12
Date	7/15	7/22	7/29	8/5	8/12	8/19	8/26	9/2	9/9	9/17	9/23	9/30
TOC (mg/l)	1.2	1.9	1.6	1.7	1.95	2.01	2.4	3.3	3.2	3.8	3.7	4.4
DOC (mg/l)	1.6	1.5	1.41	1.68	1.78	1.69	1.7	2.2	2.3	2.4	2.5	2.4
UVA cm^{-1}	0.02	0.024	0.021	0.021	0.022	0.022	0.026	0.031	0.039	0.041	0.042	0.042
Specific Absorbance	1.25	1.6	1.49	1.25	1.24	1.3	1.53	1.41	1.7	1.71	1.68	1.75
Alkalinity (mg/l as $CaCO_3$)	41		42		44		47		53		54	58
Ammonia (mg/l as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
Bromide (mg/l)	<0.01			<0.01	<0.01			<0.01		0.01		<0.01
Nitrate + Nitrite (mg/l as N)	<0.01				<0.01							<0.01
Total Kjeldahl Nitrogen (mg/l as N)	0.2		0.1		0.2		0.6		0.9		0.7	0.8
Total Phosphorus (mg/l as P)	0.12		0.07		0.14		0.13		0.09		0.06	0.07
Dis. Orthophosphate (mg/l as P)	0.06				0.04							<0.01
Bromodichloromethane (µg/l)	6	6	<10	6	6	7	8	7	<10	<10	<10	<10
Bromoform (µg/l)	<1	<1	<10	<1	<1	<1	<1	<1	<10	<10	<10	≤10
Chloroform	79	74	81	73	74	70	85	91	130	130	160	150

Weeks	1	2	3	4	5	6	7	8	9	10	11	12
Date	7/15	7/22	7/29	8/5	8/12	8/19	8/26	9/2	9/9	9/17	9/23	9/30
(µg/l)												
Dibromo-chloro-meth-ane (µg/l)	<1	<1	<10	<1	<1	<1	<1	<1	<10	<10	<10	<10
Total THMFP (µg/l)	85	80	81	79	80	77	93	98	130	130	160	150
Chlorophyll-a (µg/l)	5.72	3.17	2.7	2.65	6.34	8.67	28.4	83.5	62.6	38.4	76.4	88.5
Pheophytin-a (µg/l)	<.01	<.01	0.515	<0.01	0.793	0.13	0.969	2.3	8.3	15.5	9.93	10.7
Field EC (µS/cm)	135	137	140	141	145	144	146	150	151	150	154	153
Field DO (mg/l)	9.2	6.8	6.4	5.3	5.22	6.5	10.95	12.8	9.7	9.9	11.1	11.6
Field pH	7.4	6.5	6.8	7.1	6.5	6.66	7.76	8.58	8.4	8.6	8.5	7.4
Field Turbidity (ntu)	1.75	1.2	0.82	0.79	1.13	1.39	3.13	3.59	2.39	2.27	2.77	3.37

3. Peat Soil

A grab sample of peat soil was scooped from each tank for laboratory analyses performed by BSK Laboratories. The methods for soil analysis were:

Analyte	Method
Bromide	EPA 300.0
Nitrate	EPA 300.0
Total N	Standard Methods 4500-N
TKN	Standard Methods 4500-Norg-C
Organic Matter	Walkley-Black
Organic Matter Gravimetric (%)	ASTM D2974
Total P	Standard Methods-P-B

The percent organic matter ranged from 22 to 33 on a gravimetric basis. TKN ranged from 3500 to 5200 mg/Kg. Overall, the results showed that peat soil is naturally enriched in organic carbon and nutrients (Appendix B).

The reported total P ranged from 0.42 to 2.7 mg/Kg, however, it was later discovered that the soil digestion method (perchloric acid) used by BSK Laboratories tends to underestimate total P in proportion to the quantity of P imbedded in the matrix of minerals (SSAJ, 1996). The total P concentration in soils generally is in the range of 200 to 5000 mg P/Kg with an average of 600 mg P/Kg (Lindsay, 1979). The bromide levels were reported at <2.5 mg/Kg in all soil samples. However, these results are also suspect. Bromide concentrations of mineral soils range from 0.3 to 40 mg/Kg (average about 6 mg/Kg) and in peat soils range from 12 to 70 mg/Kg (average about 30 mg/Kg) (Vinogradov, 1959).

The data also indicated that the characteristics of the peat soil in the tanks were not homogeneously distributed as soil is a heterogeneous mass. It is difficult to achieve a perfect blend of peat soil when that soil can vary both horizontally and vertically in a field. This wide range in properties, such as the percentage of organic carbon in soil, has been seen in the Delta fields. A DWR-USGS cooperative study found soil organic carbon concentrations at a Twitchell Island agricultural field to range from 18.3 to 27.7 percent for near-surface soils (0.5 to 1.5 ft. below land surface). It was 25.2 to 36.9 percent organic carbon for soils taken from 4.5 to 6.0 feet below land surface (Fujii et. al., 1998). These variations in the peat soil characteristics may have affected the experimental results.

Duties of the principal investigators included tamping down and leveling the peat soil inside the tanks and collecting composite samples from the soil surface for laboratory analyses prior to filling the tanks with water.

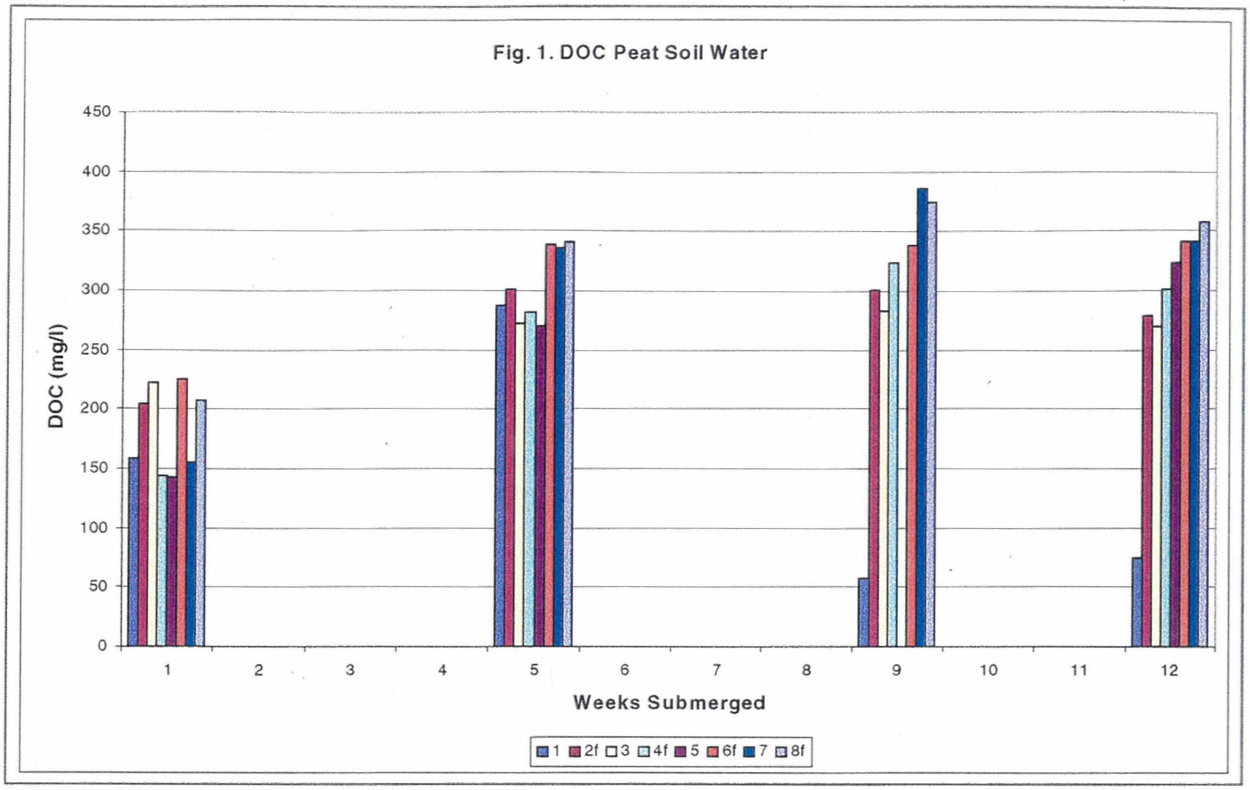
4. Peat Soil Water Quality

Peat soil water samples were taken from a sampling port located 0.5 ft. from the bottom of each tank. These samples represented either water taken 1 ft. below or 3.5 ft. below the soil-water surface depending on the height of peat soil (1.5 or 4 ft.) in the tanks sampled. Samples were taken after 1, 5, 9, and 12 weeks of submergence.

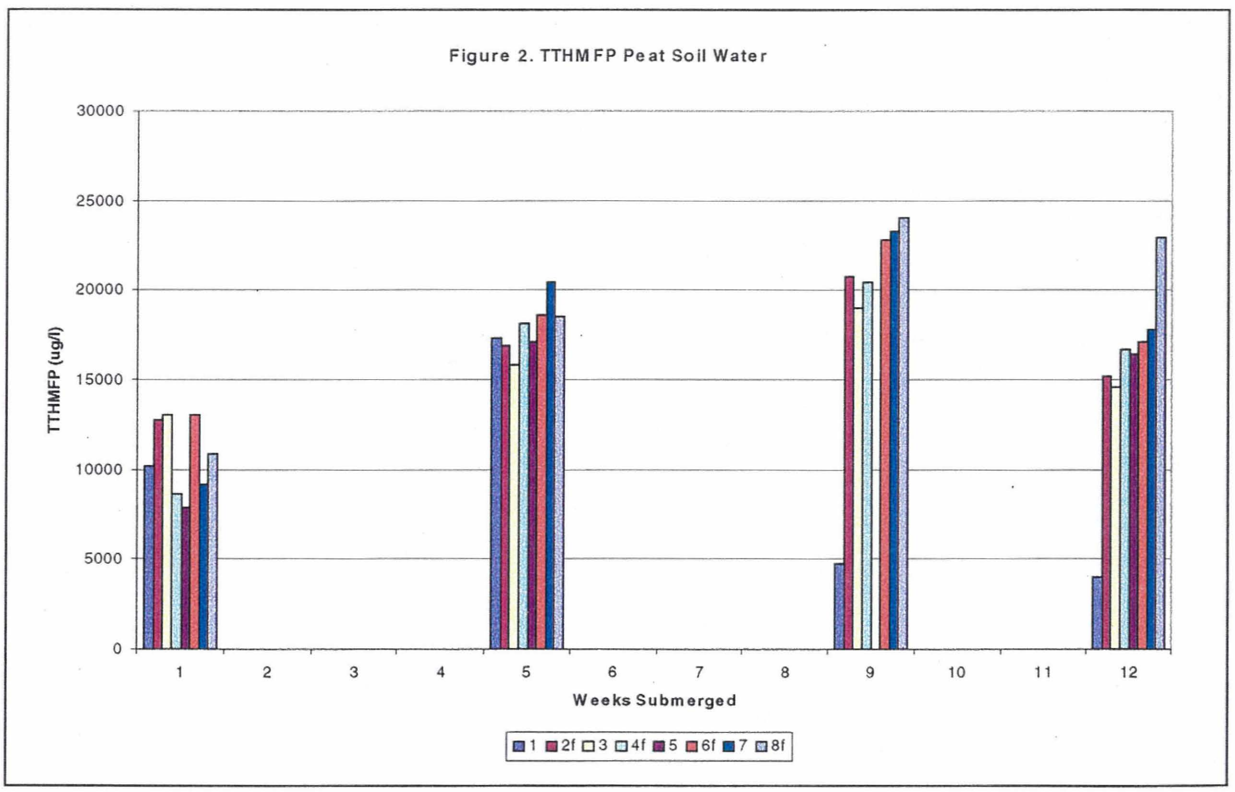
In general, monthly trends showed progressive increases in DOC, TTHMFP, nutrients, specific UVA-254nm absorbance, alkalinity, and bromide levels due to a continuous dissolution and decomposition of matter in the waterlogged peat soil.

Significant changes in peat soil water quality in tank 1 were seen at the third-month sampling event (September 9). Parameters, such as TOC, DOC, EC, phosphates, and TKN, were less than the second month observations (August 12). TOC fell from 287 mg/l at the second month sampling to 64.5 mg/l at the third month sampling event. We believe that this was due to previous withdrawals of water samples. Tank 1 had a 2 ft. water depth over a 1.5 ft. deep layer of peat soil. ***Since the peat soil water sampling port was located at 0.5 ft. above the tank bottom, we concluded that we were beginning to sample water from the transition zone or boundary layer (top 1 ft. of flooded soil) that was affected by the quality of the surface water. Therefore, the peat soil water quality in tank 1 and possibly in some other tanks at the end of the experiment may, in part, reflect decreases in concentrations due to water being withdrawn (i.e., drained) from the upper transition zone.***

DOC concentrations in the water-saturated peat layer had nearly doubled after a month of submergence in all tanks (Figure 1). The average initial DOC concentrations were about 150 mg/l. By the end of the first month, the average was about 300 mg/l. The rapid DOC increase is indicative of the breakdown and dissolution of the large pool of organic matter in the peat. Slight decreases in DOC during the last month could be attributed to transformation of DOC compounds to carbon dioxide and methane gases. The initial large increase in DOC could be, in part, an indicator of rapid decomposition of a high cellulose content in soil organic matter. The smaller differences in the DOC change at the end of the experiment might be due to slower degradation of the more resistant lignin substances remaining. After 12 weeks of submergence, TOC concentrations in tanks 2 to 8 ranged from 276 to 373 mg/l and DOC levels were 270 to 358 mg/l.



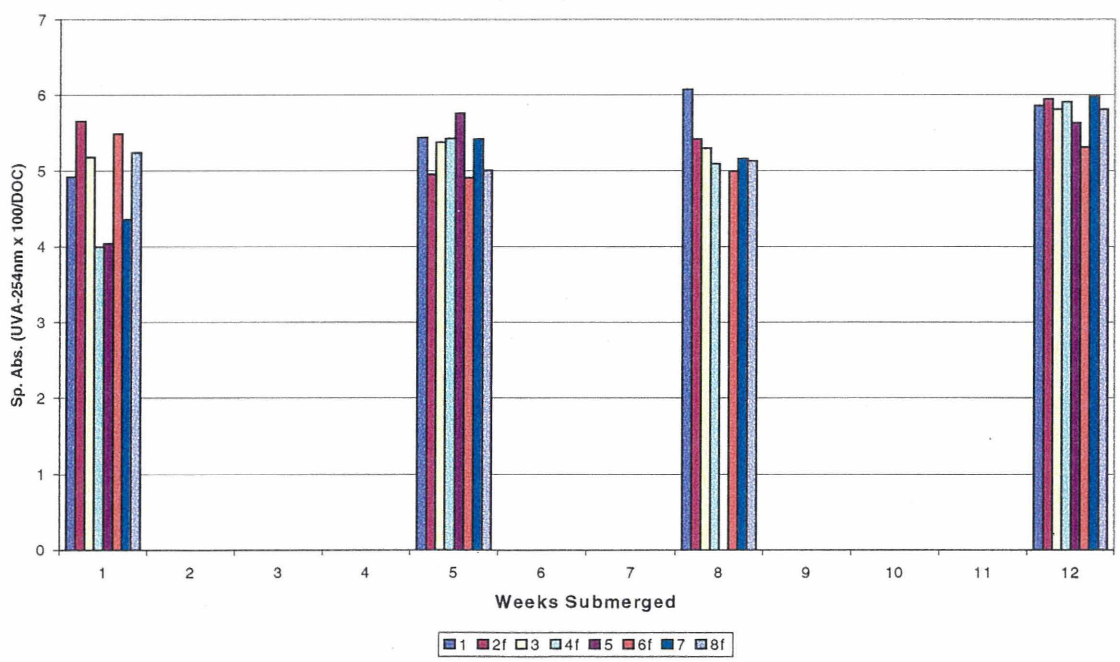
The reactivity-based TTHMFP concentrations in the peat soil water followed the DOC trend (Figure 2). By the fifth week, the TTHMFP levels had increased by an average of 73.5 percent from the first week of flooding.



There is a known positive relationship between UV absorbance and organic carbon concentration in water (AWWARF, 1988). Organic compounds with C=C bonds, such as humic substances, absorb ultraviolet light at the wavelength of 254 nm. Humic substances have been identified as the organic compounds that react with disinfectants to form trihalomethanes and other disinfection byproducts. Peat soil is high in humic matter due to decomposing plant material. A ratio, called specific ultraviolet absorbance (SUVA), was computed by multiplying the UVA-254 nm readings by 100 and then dividing by the DOC concentrations of the samples. The ratio is useful in estimating the transformation rate of organic carbon in the peat soil. SUVA increased quickly and humification may have begun to slow down after 12 weeks of submergence (Figure 3). However, an extended experiment is needed to substantiate that conclusion and to determine statistical significance of the changing SUVA values.

Historic MWQI data show that SUVA values are generally above 3 for Delta island drain water and about 2 in rivers (e.g., American River) above the Delta. Delta drain waters have a range of SUVA values depending on location and season. The peat soil SUVA results support earlier hypotheses about the relationship of SUVA and aging or transformation of organic carbon to humic compounds (DWR, 1990). The experimental results suggest that SUVA values might be a useful indicator of the estimated water to soil contact time of drainage in the Delta. Experiment #2 may test this hypothesis.

Figure 3. Specific UV Absorbance
Peat Soil Water



The synthesis of organic nitrogen compounds in plant and animal tissue and the metabolic processes of protoplasm produce various compounds with nitrogen. These organic nitrogen compounds include, for example, nitrogen in combination with carbon and other elements, protein, amino acids, and uric acid and urea as animal metabolic wastes (Reid, 1961). Microbial decomposition of organic matter results in the release of nitrogen in the ammonium form (NH_4^+) through the process called ammonification. Under good aeration and favorable temperatures, different microorganisms oxidize the ammonium first to nitrite (NO_2^-) and then to nitrate (NO_3^-), a process called nitrification. The conversion of nitrite to nitrate is usually faster than from ammonium to nitrite, so that practically no nitrite accumulates. If the ammonia content (NH_3) is high, however, nitrite may accumulate. Ammonia is toxic to many organisms. If nitrate is exposed to anaerobic conditions, it will be reduced (denitrification) to gaseous molecular nitrogen (N_2) or nitrous oxide (N_2O) and lost to the atmosphere (Biggar and Corey, 1969). Ammonium ions are held on the cation-exchange sites in soils so ammonium levels in soil solution is not very high. Nitrate anion is soluble and it freely moves with soil water. Ammonium nitrogen often accumulates in wetland soils because anaerobic conditions favor the reduced ionic form over the nitrate form. Four forms of nitrogen were monitored. They were organic nitrogen (total Kjeldahl nitrogen), nitrate, nitrite, and ammonia.

Total Kjeldahl Nitrogen generally increased over time as soluble organic nitrogen was produced from peat degradation and increasing microbial biomass in the peat soil layer (Figure 4). Corresponding increases in ammonia concentrations (Figure 5) were observed and indicated rapid deamination of organic nitrogen compounds. Initial TKN concentrations were 12 to 18 mg/l. Final TKN levels were 30 to 35 mg/l in some tanks. In general, ammonia levels were two to four times higher by the end of the experiment. The accumulation of ammonia due to anaerobic conditions in the peat soil water agrees with what is known about the nitrogen cycle. The continuous evolution of gas bubbles from the peat soil also suggests that denitrification occurred.

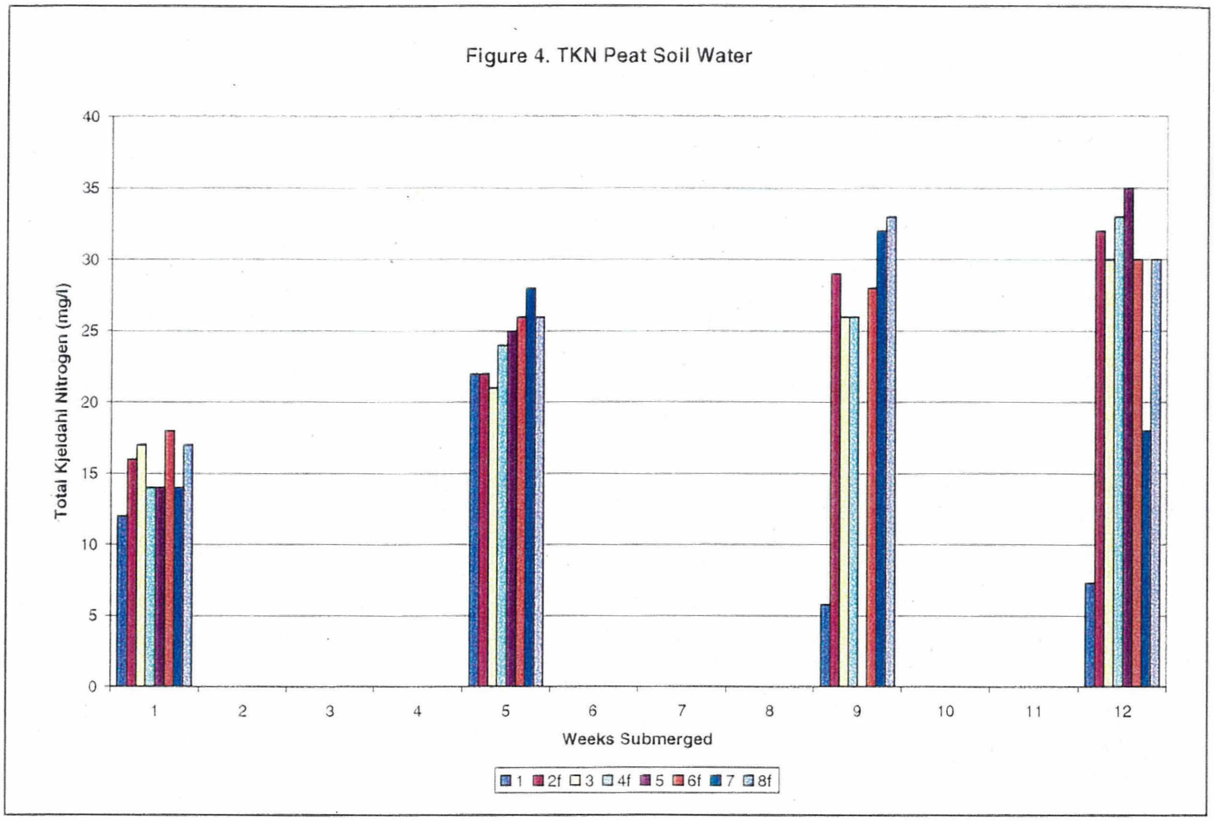


Figure 4. TKN Peat Soil Water
Total Kjeldahl Nitrogen (mg/l)
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
Weeks Submerged
1 2f 3 4f 5 6f 7 8f

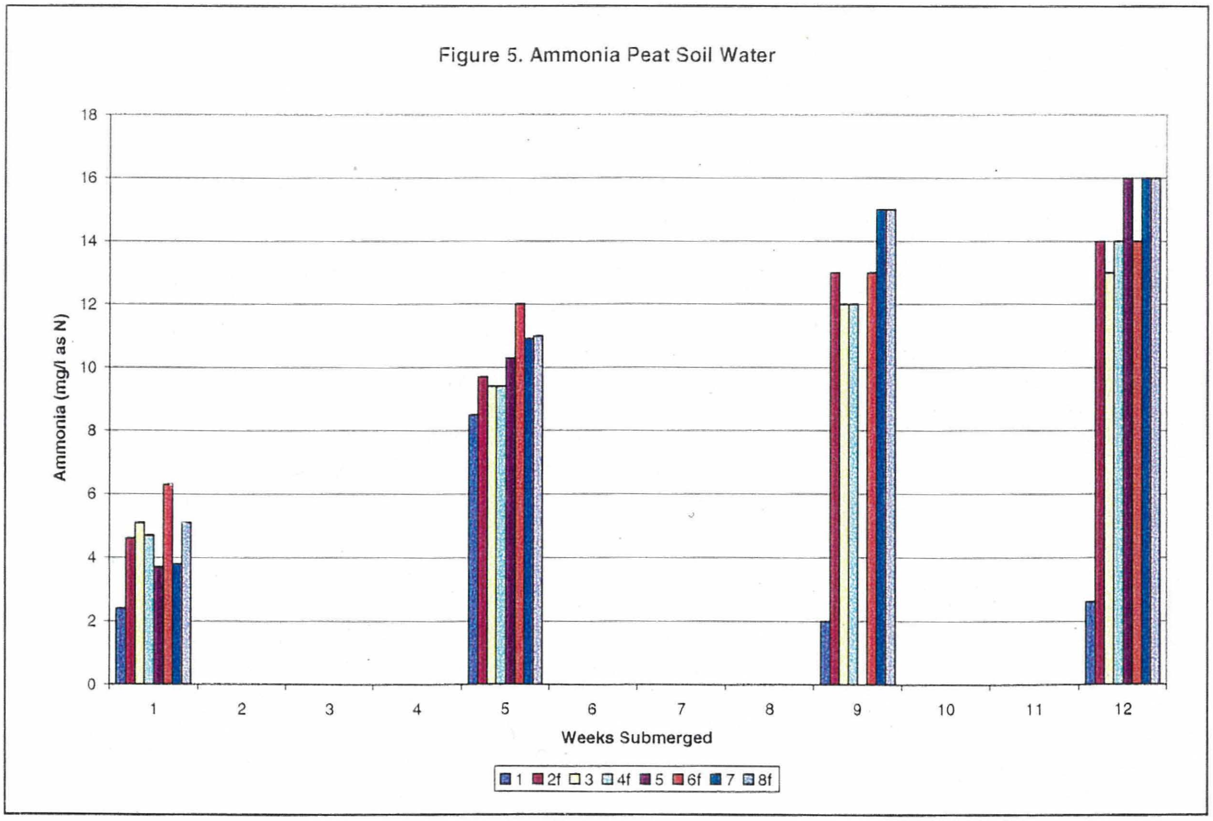
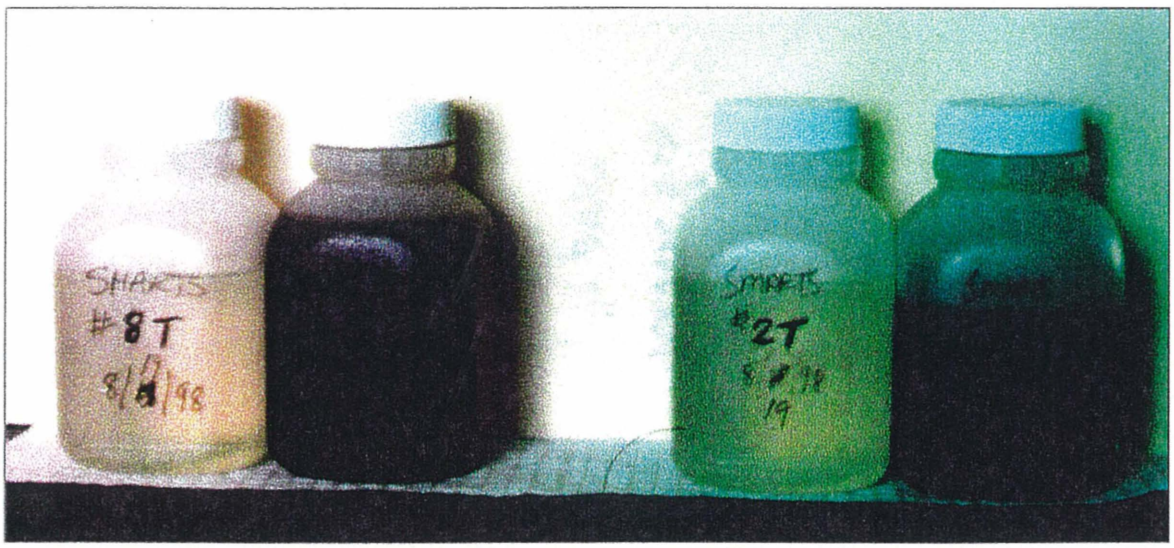


Figure 5. Ammonia Peat Soil Water
Ammonia (mg/l as N)
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
Weeks Submerged
1 2f 3 4f 5 6f 7 8f

Oxidizable nitrogen concentrations, which are reported as nitrate plus nitrite, were unchanged during the experiment. Concentrations were at or below 0.020 mg/l as N. This resulted because anaerobic conditions in the peat soil water prevented nitrification. Upward diffusion of ammonia and soluble organic matter to the submerged aerobic soil surface layer would allow microorganisms to convert these forms to higher oxidation forms.

Anoxic and acidic conditions existed in the saturated peat soil layer and mobilized phosphorus compounds as seen by the total phosphorus and dissolved orthophosphate concentrations (Figures 6 and 7, respectively). This is partially caused by the hydrolysis and reduction of ferric and aluminum phosphates to more soluble compounds that occur under anaerobic conditions. Phosphorus can also be released from insoluble salts when the pH is changed by the production of organic acids or by the production of nitric and sulfuric acids by chemosynthetic bacteria (Atlas and Bartha, 1981). Under aerobic conditions, phosphorus tends to be bound or precipitated with ferric iron, calcium, and aluminum to form insoluble phosphates.

The nitrogen and phosphorus results showed that there is a large supply of nutrients available in flooded peat soil due to the anoxic conditions, which can diffuse upward to enrich the oxygenated surface water.



The color differences between filtered surface water (light) and peat soil water (dark) samples were significant. These samples were taken from tanks 8f and 2f one month after the experiment began. Peat soil water samples had a strong hydrogen sulfide odor.

Figure 6. Total Phosphorus Peat Soil Water

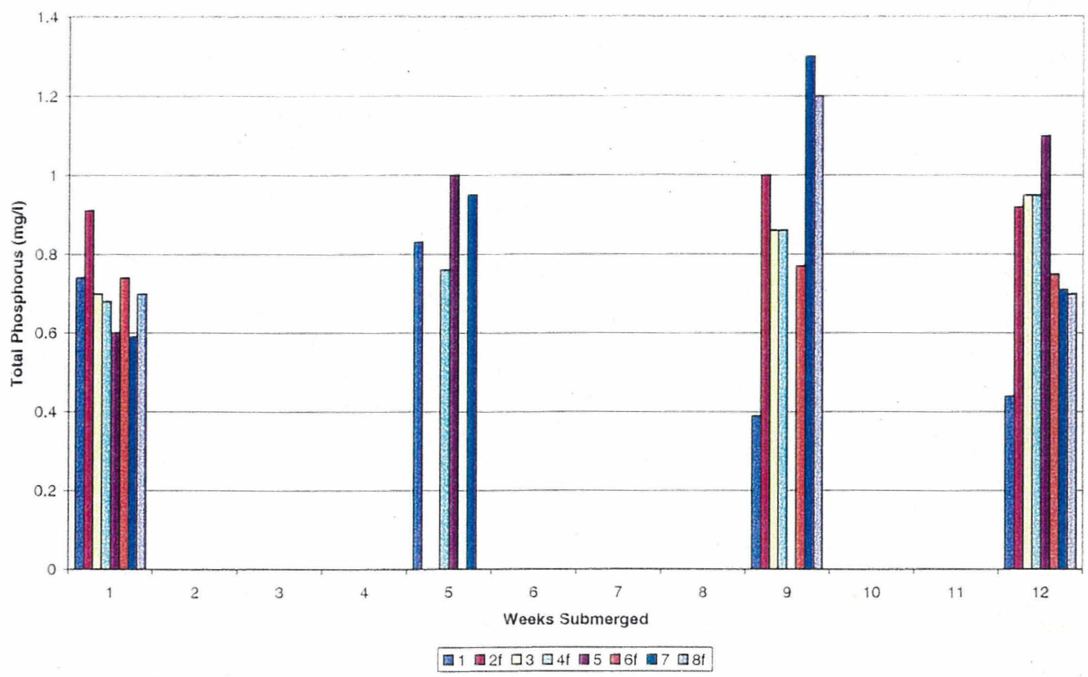
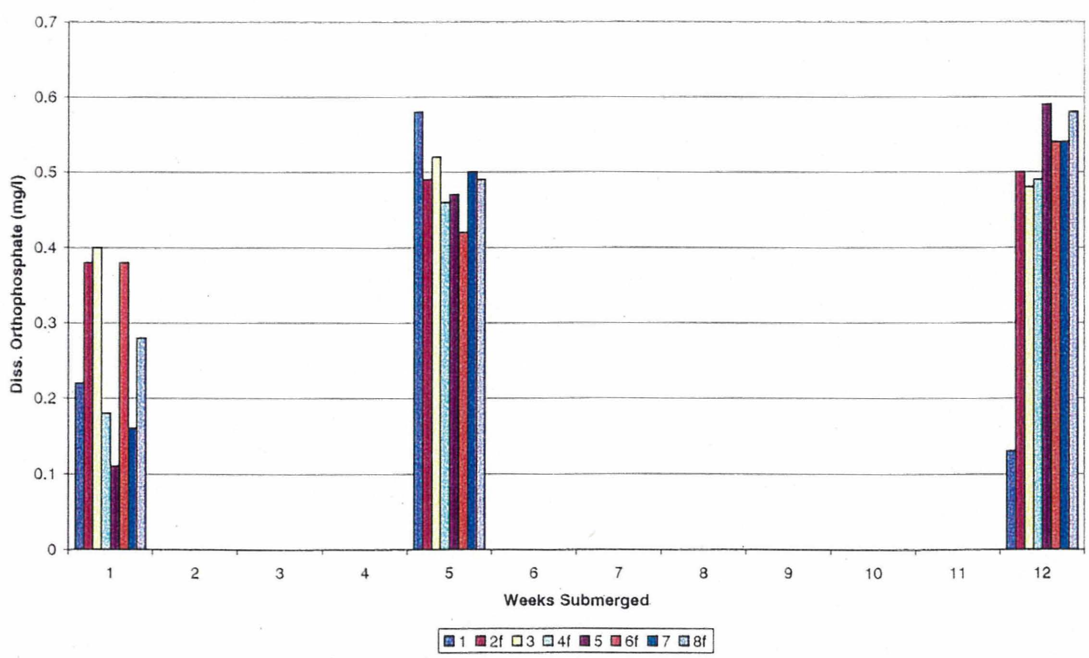
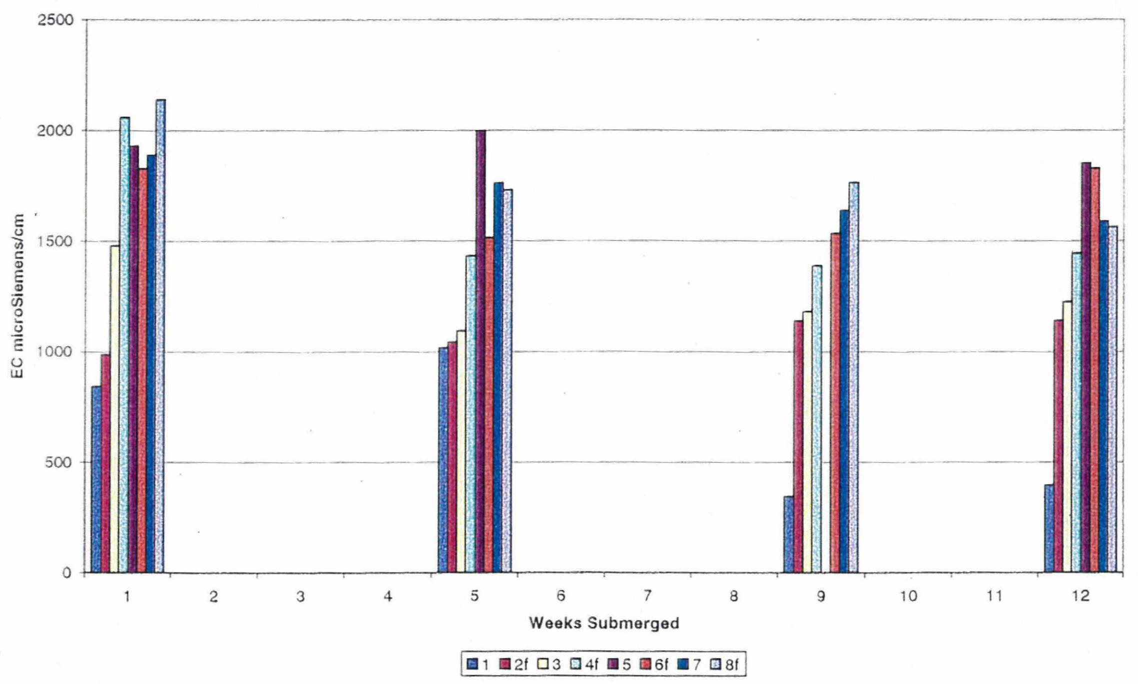


Figure 7. Diss. Orthophosphate
Peat Soil Water



The trends in specific conductance or electrical conductivity readings varied. Some tank EC readings increased while others decreased (Figure 8). Some of the variations could have been due to interrupted and unsteady flows of added water in the small tanks during the first month and/or shifts in the dissolution (e.g., deamination) and precipitation of minerals (e.g. insoluble phosphates, sulfides) as anaerobic conditions prevailed. The latter explanation is the likely cause as we do not expect added surface water could affect the EC at the bottom of the tanks. The declines in tank 1, which had 1.5 feet of peat is likely due to withdrawal of water close to the soil-water surface since the sampling port was located about a foot below.

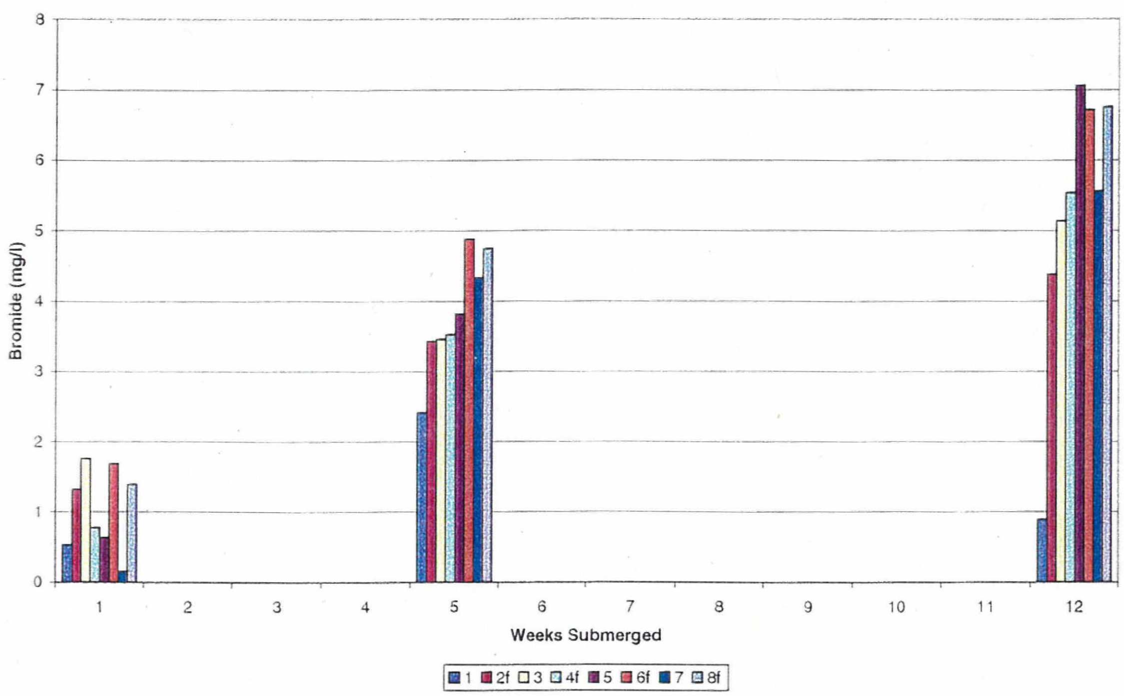
Figure 8. EC Peat Soil Water



Bromide concentrations, however, appeared to steadily increase over time (Figure 9). We cannot determine what proportion of EC and bromide increases were due to the dissolution of land-derived salts in the peat soil or from the breakdown of organic matter in the peat soil. Future work should examine the source of bromides in peat soil.

The mineralization of organic sulfur to inorganic sulfide was evident by the first week of flooding. Strong hydrogen sulfide gas odors (rotten egg smell) were observed in all peat soil water samples and in the following sampling events. We conclude that rapid oxygen depletion occurred within days of flooding and anaerobic conditions caused sulfide reduction in the soil column. Most organic sulfur in living tissue is in the S-containing amino acids and sulfate esters (e.g., cysteine). In soil, 90 % of the sulfur is organic with 50% in C-O-S linkages (sulfate esters), 20 % in S-amino acids, and the remaining 20 % in a range of different sulfur compounds (www.bsi.vt.edu, 1999). Gas ebullition was seen in the tanks for several weeks. We attribute the anoxic conditions and initial low pHs (< 6) to rapid and high microbial respiration and soil enzyme activities during the warm summer. Over time alkalinity and pH levels increased. The increasing alkalinity (300 – 600 mg/l) likely buffered the initial low pHs, resulting in raising the pH. Nutrient conversions and TOC levels appeared to increase less after the second month. This probably reflected slower microbial activity in the soil over time with lower CO_2 production, which also helped raise the pH as less carbonic acid was produced or neutralized.

Figure 9. Bromide Peat Soil Water



Overall, peat soil water quality did not appear to stabilize after 12 weeks of submergence. Most, if not all, water quality constituents and field measurements continued to change each month. The data are in agreement with similar observations of subsurface water quality under agricultural fields in the peat islands and tracts of the Sacramento-San Joaquin Delta. The higher concentrations observed in this experiment than in the field is attributed to the absence of a drainage simulation of the subsurface water in the SMARTS tanks. Experiment #2 results will provide a year's worth of data to determine if peat soil water quality changes with season.

5. Surface Water Quality

Surface water samples were collected each week. The tanks with no continuous water exchange (1,3,5,7) had higher concentrations of all water quality parameters than those tanks (2,4,6,8) with water exchange. The tank pairs (no exchange vs. with exchange) for comparison are:

(1) tank 1 vs. 2f (1.5 ft. peat and 2 ft. water)
(2) tank 3 vs. 4f (4 ft. peat and 2 ft. water)
(3) tank 5 vs. 8f (4 ft. peat and 7 ft. water)
(4) tank 7 vs. 6f (1.5 ft. peat and 7 ft. water)
(5) tank 9 materials test control (no peat and 11 ft. water)

At the tenth week of the study, it appeared that the TOC and DOC concentrations had begun to stabilize in the tanks except possibly in tank 3.

Organic Carbon Concentrations At Tenth Week of Flooding

Tank	TOC (mg/l)	Rank (highest to lowest TOC)	DOC (mg/l)	Rank (highest to lowest DOC)
1	***38***	***2***	***39.4***	***2***
2f	6.2	6	5.2	6
3	***166***	***1***	***108***	***1***
4f	8.3	5	8.3	5
5	***33.3***	***3***	***26***	***3***
6f	3	8	2.8	7
7	***17.7***	***4***	***16.5***	***4***
8f	2.3	9	1.9	9
9	3.8	7	2.4	8

The highest TOC and DOC concentrations (in decreasing order) were in the group of tanks with no continuous water exchange --tanks 3, 1,5, and 7 (Figures 10 and 11). TOC was the highest (166 mg/l) in tank 3, which held four feet of peat under two feet of water with no water added until after the tenth week sampling event. The decline in TOC, TTHMFP, and EC seen in tank 3 at the last two weeks of the study resulted from this dilution. The tank 3 results were similar to a USGS study on Twitchell Island that found 150 to 220 mg/l DOC for a shallow wetland-habitat test pond (30 cm. deep, 85-m^2) that was flooded from early spring through July then drained (Fujii et.al., 1998).

The TOC and DOC in tank 1 reached 41.5 mg/l and 40.3 mg/l, respectively, at the end of the study.

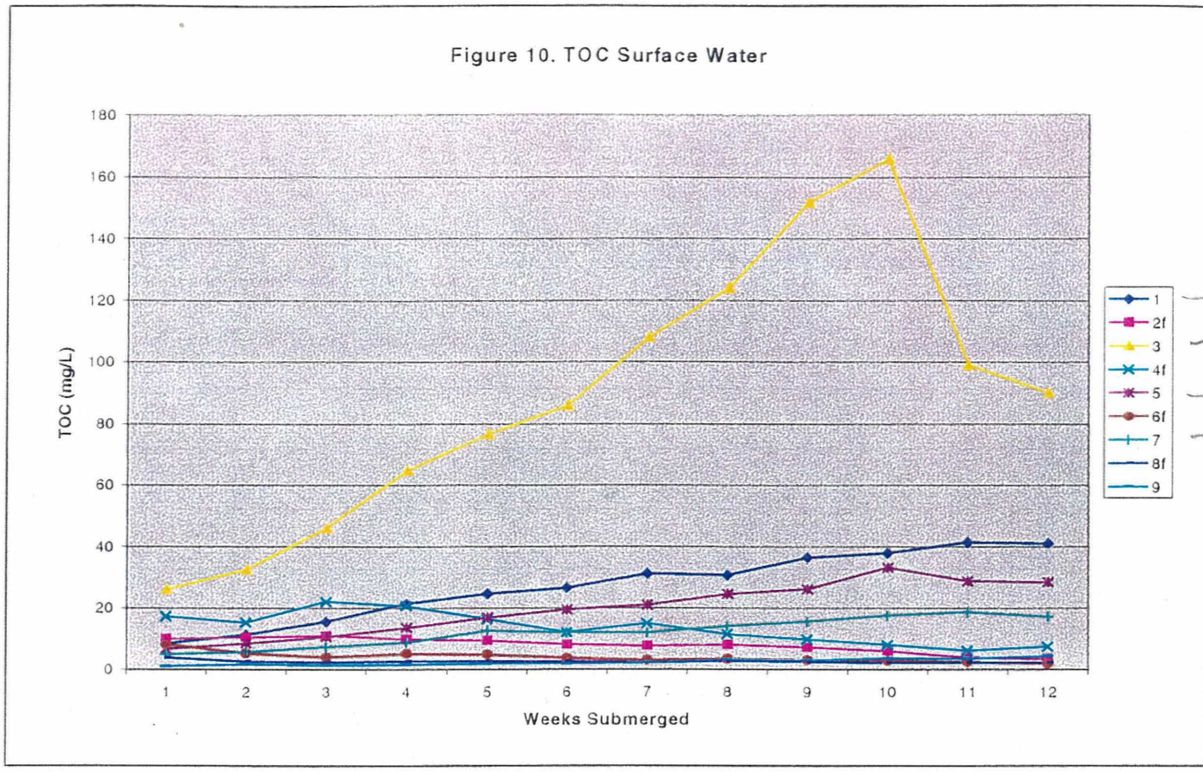


Figure 10. TOC Surface Water

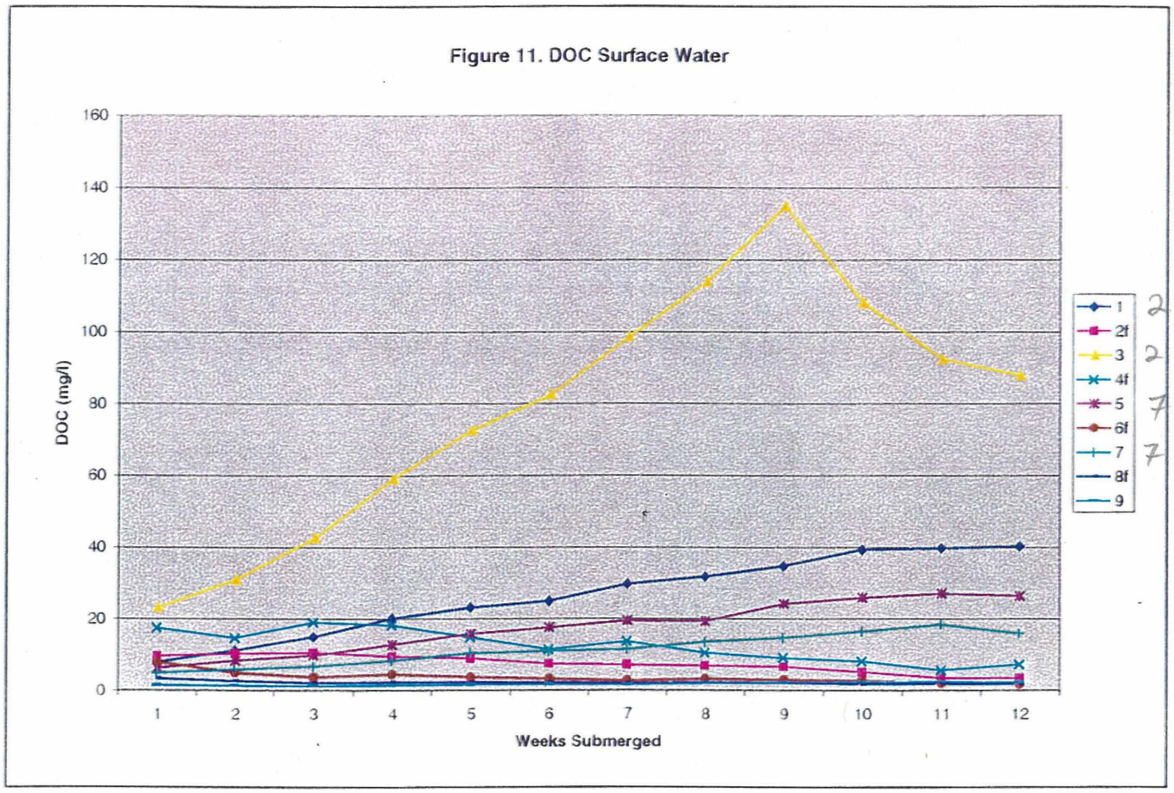
1.5 x 2
4 x 2
4 x 7
1.5 x 7

Note: Water was added to tank 3 after the tenth week samples were taken. The dilution affected subsequent tank 3 water quality.

TOC (mg/l) Surface Water

Tank/Week	1	2	3	4	5	6	7	8	9	10	11	12
1	8.7	11.4	15.7	21.5	24.7	26.6	31.3	30.8	36.6	38.0	41.5	41.2
2f	10.1	10.6	11.2	9.9	9.6	8.2	7.9	8.1	7.4	6.2	4.1	3.6
3	26.2	32.6	46.3	64.9	76.7	86.0	108.0	124.0	152.0	166.0	99.1	90.2
4f	17.5	15.5	22.3	20.9	16.5	12.2	15.1	11.7	10.0	8.3	6.3	7.6
5	6.7	8.6	10.8	13.6	17.0	19.6	21.1	24.6	26.2	33.3	28.9	28.5
6f	8.2	5.4	4.2	5.2	5.0	3.8	3.2	3.6	3.2	3.0	2.5	2.0
7	5.1	5.9	7.5	8.9	12.7	12.1	12.1	14.2	15.7	17.7	18.7	17.3
8f	3.9	2.8	2.5	2.8	2.7	2.6	2.3	2.9	2.6	2.3	2.3	2.4
9	1.2	1.9	1.6	1.7	2.0	2.0	2.4	3.3	3.2	3.8	3.7	4.4

$\bar{x}$ = 89



2' 295
2'
7 1028
7

Note: Water was added to tank 3 after the tenth week samples were taken. Dilution affected subsequent tank 3 water quality.

DOC (mg/l) Surface Water

Tank/Week	1	2	3	4	5	6	7	8	9	10	11	12
1	8.0	11.3	15.1	20.2	23.3	25.0	29.8	31.9	34.8	39.4	39.8	40.3
2f	9.7	10.4	10.7	9.6	9.0	7.5	7.3	7.6	6.7	5.2	3.6	3.6
3	23.3	31.0	42.6	59.2	72.7	82.6	98.7	114.0	135.0	108.0	92.4	87.9
4f	17.6	14.8	19.1	18.4	15.0	11.5	13.8	10.7	9.2	8.3	5.8	7.4
5	6.3	8.4	9.9	12.8	15.9	17.7	19.6	19.4	24.3	26.0	27.2	26.4
6f	8.1	5.0	3.8	4.6	3.8	3.4	2.8	3.3	3.0	2.8	2.1	1.9
7	5.0	5.9	6.9	8.5	10.5	11.0	11.5	13.6	14.8	16.5	18.5	16.0
8f	3.5	2.8	2.2	2.4	2.4	2.3	2.2	2.3	2.3	1.9	2.0	1.8
9	1.6	1.5	1.4	1.7	1.8	1.7	1.7	2.2	2.3	2.4	2.5	2.4

79

The effect of peat soil mass was seen between tanks 5 and 7, which had 4 ft. and 1.5 ft. of peat, respectively, under 7 feet of water. Tank 7 TOC and DOC were about half of the Tank 5 concentrations. By week 10, tanks 5 and 7 TOC were 33.3 and 17.7 mg/l, respectively. The difference between tanks 1 and 3, which had 1.5 ft. and 4 ft. of peat, respectively, under 2 feet of water was more significant. Tank 1 TOC was at 23 percent and DOC at 36 percent of the tank 3 values.

As a group, the tanks with continuous water exchange had the lowest TOC concentrations. By week 10, TOC in tanks 2f, 4f, 6f, and 8f were 6.2, 8.3, 3.0, and 2.3 mg/l, respectively. The lowest TOC concentrations during the study were in tanks 6f and 8f. TOC were at or below 3 mg/l in tanks 6f and 8f by the tenth and second week, respectively. The difference in time to reach 3 mg/l or less of TOC was probably due to a higher initial TOC in tank 6f (8.2 mg/l) than tank 8f (3.9 mg/l).

The differences between tank 2f and 4f also appeared to be related to peat soil mass. Tank 2f had 1.5 feet of peat and tank 4f had 4 feet of peat with both tanks continuously flooded to 2 feet at an exchange rate of about one volume per week.

Overall, the DOC trend followed the TOC trend except that TOC peaked at week 10 and the DOC concentration peaked at week 9 in tank 3. Dilutions of TOC or DOC (Figures 10 and 11) did not appear to be a simple mixing ratio as expected with conservative constituents. Tanks 5 and 7, each with 7 feet of surface water, were not 3.5 times less in concentrations of DOC than tanks 1 and 3 that had 2 feet of water for the same amount of peat soil mass. While a fraction of TOC and DOC pool may behave conservatively, much of the organic pool as seen in a highly reactive environment during a short time period is not conservative. A conservative behavior appears over time as the less biodegradable material remains.

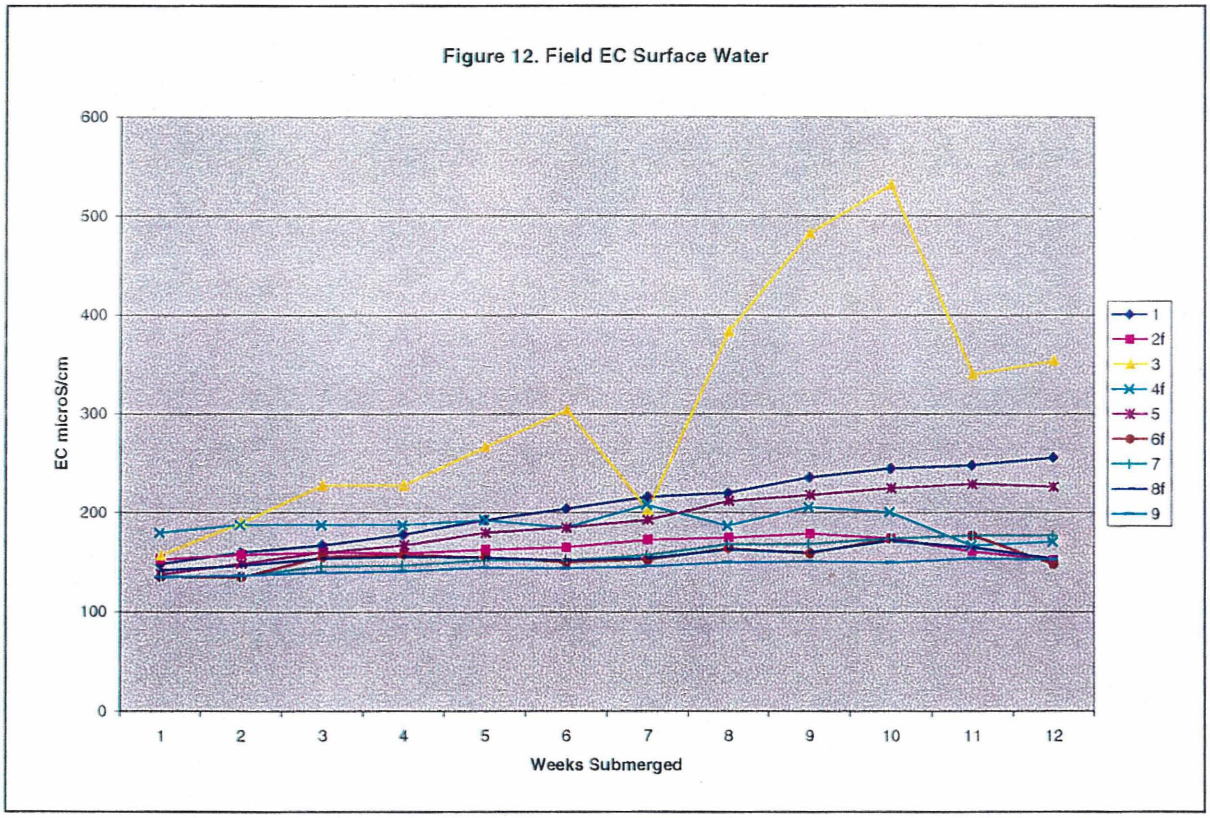
Comparison of DOC in Shallow and Deep Flooded Tanks
After 10 Weeks of Submergence

Peat depth	Water depth	Tank 1 vs. Tank 7 DOC (mg/l)	Tank 3 vs.Tank 5 DOC (mg/l)	Dilution ratio
1.5'	2' vs. 7'	39.4 16.5		2.4
4'	2' vs. 7'		108 26	4.15

The effects of evaporation in the tanks with no continuous water exchange were seen by a gradual increase of EC over time (Figure 12). EC readings were lower and rose less in the tanks with constant water exchange. The anomalous sharp EC dip and then returning rise in tank 3 at weeks 7 and 8 cannot be explained other than due to perhaps an instrument malfunction or recording error. No water was added prior to week 7 that could have diluted the EC in tank 3. Water (60 gal.) was added to tank 3 after the week 10 sampling event and that did result in the lower EC reading on week 11. The EC dropped by 36 percent from 532 to 340 µS/cm after adding about 20 percent of the estimated surface water volume. The effects of frequent water additions to tank 7 were not apparent as the water supply EC (Table 3) was about the same as the EC in the tank at those times. EC in tank 9, the materials control tank, increased from 135 to 153 μS/cm, a 13 percent increase.

Comparison of EC in Shallow and Deep Flooded Tanks
After 10 Weeks of Submergence

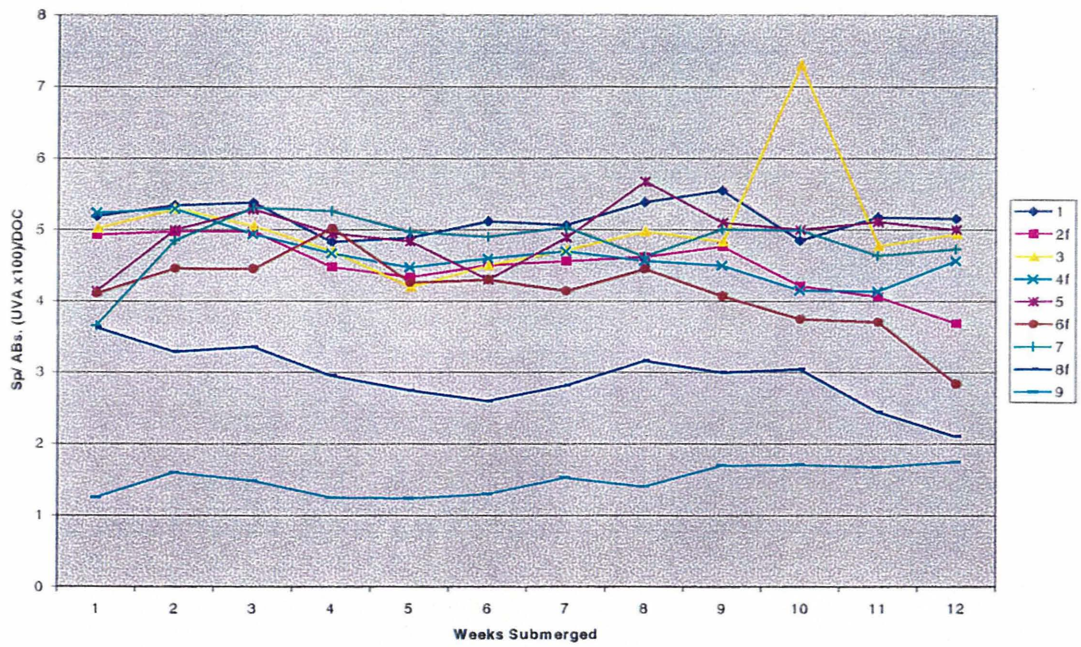
Peat depth	Water depth	Tank 1 vs. Tank 7 EC μS/cm	Tank 3 vs. Tank 5 EC μS/cm	EC in deep tank as a % of the EC in shallow tank
1.5'	2' vs. 7'	245 174		71
4'	2' vs. 7'		532 225	43



Note: Water was added to tank 3 after the tenth week samples were taken. Dilution affected subsequent tank 3 water quality.

Specific UV absorbance values declined in the tanks with water exchanges (2f, 4f, 6f, 8f) over time and final values were less than those with no exchange (Figure 13). TOC and SUVA in tanks 6f and 8f (both filled with 7 ft. of water) approached the values in tank 9, the tank with no peat soil and 11 feet of water. The SUVA values in the tanks with flow were in the range of those seen in the Delta channels (DWR, 1994) and show the importance of large dilutions and water exchanges in regulating TOC and SUVA. SUVA in the tanks with no water exchange were 3 to 6, typical of Delta island drainage. The SUVA value for tank 3 at week 10 is unusually high and may be due to an erroneous DOC value. The sample had a reported TOC of 166 mg/l and DOC of 108 mg/l. Usually, the DOC levels are within 15 percent of the TOC concentration.

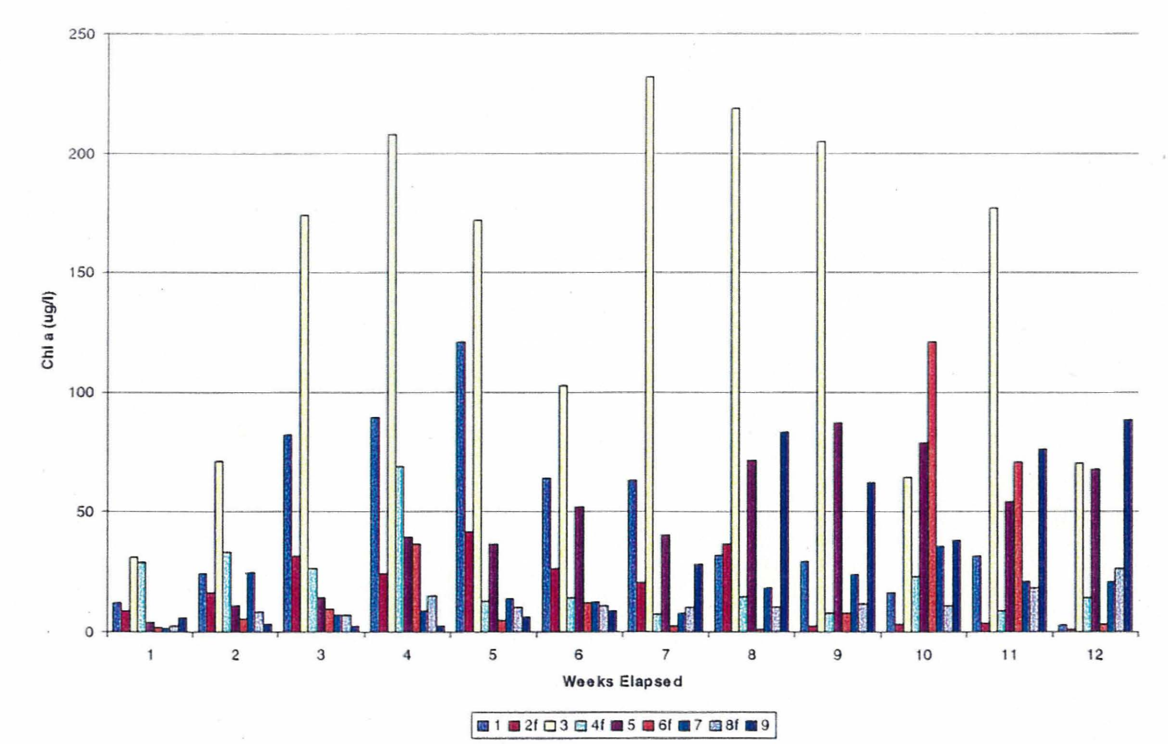
Figure 13. Specific Abs. Surface Water



Note: Water was added to tank 3 after the tenth week samples were taken. Dilution affected subsequent tank 3 water quality.

Thick algal mats grew in the tanks, especially in the small tanks (1 – 4) with only 2 feet of water. Samples for algae analysis were taken to estimate organic carbon contributions from the algae. Chlorophyll-*a* is used as an indicator of algal biomass (Figure 14). Pheophytin-*a* is a degradation product of chlorophyll-*a*. The presence or absence of the various photosynthetic pigments (e.g., chorophylls, pheophytins, chorophyllides, phophorbides) is used with other features to identify the major algal groups. Some chlorophyll-*a* and pheophytin-*a* results may underestimate some algal organic carbon from attached algae (periphyton). TOC from chlorophyll-*a* concentrations are often estimated by multiplying chlorophyll levels by 67 (APHA, 1992). This factor assumes that on the average, chlorophyll-*a* constitutes 1.5 percent of the dry weight of organic matter (ash-free weight) of algae. Based on this relationship, it would take 15 µg/l of chlorophyll-*a* to equal 1000 µg/l (1 mg/l) of organic carbon. The computed TOC from suspended algae in the tanks were relatively low in comparison to the total concentrations in the tanks attributed to the peat soil. For example, for tank 3 at a chlorophyll-*a* concentration of 200 µg/l, the organic carbon equivalent would be 13.4 mg/l when the TOC concentration was about 150 mg/l.

Figure 14. Chlorophyll-*a* Surface Water



Tank 3 $\bar{x}$ = 143

Note: Water was added to tank 3 after the tenth week samples were taken. Dilution affected subsequent tank 3 water quality.

The contribution of TOC from the algae may, however, be underestimated. Water samples were collected below the floating algal mats. The difficulty of assessing phytoplankton populations, which have patchy distributions, is well-known by fisheries biologists. Future studies of algal production at SMARTS will need to consider alternate sampling procedures. The alternative method may be to: 1) sample at or near the floating algal mass, (2) break up the mat and stir the tank and then sample a mid-depth,or (3) take many replicate samples. In this trial experiment, we followed the DWR protocol of collecting 500 ml. of water at mid-depth in our tanks. The difficulty in the repeatability of sampling water for particulate matter is shown by the large acceptable relative percent difference of 30 percent for the method. Since this study focused on the water quality of the surface water, we followed the standard field method of collecting water below the surface. Vertical EC profiles indicated that the dissolved constituents were probably homogeneously dispersed by the submersible pumps in each tank. The confounding effect of algal blooms in Experiment #2 should not be encountered as the tanks are covered.

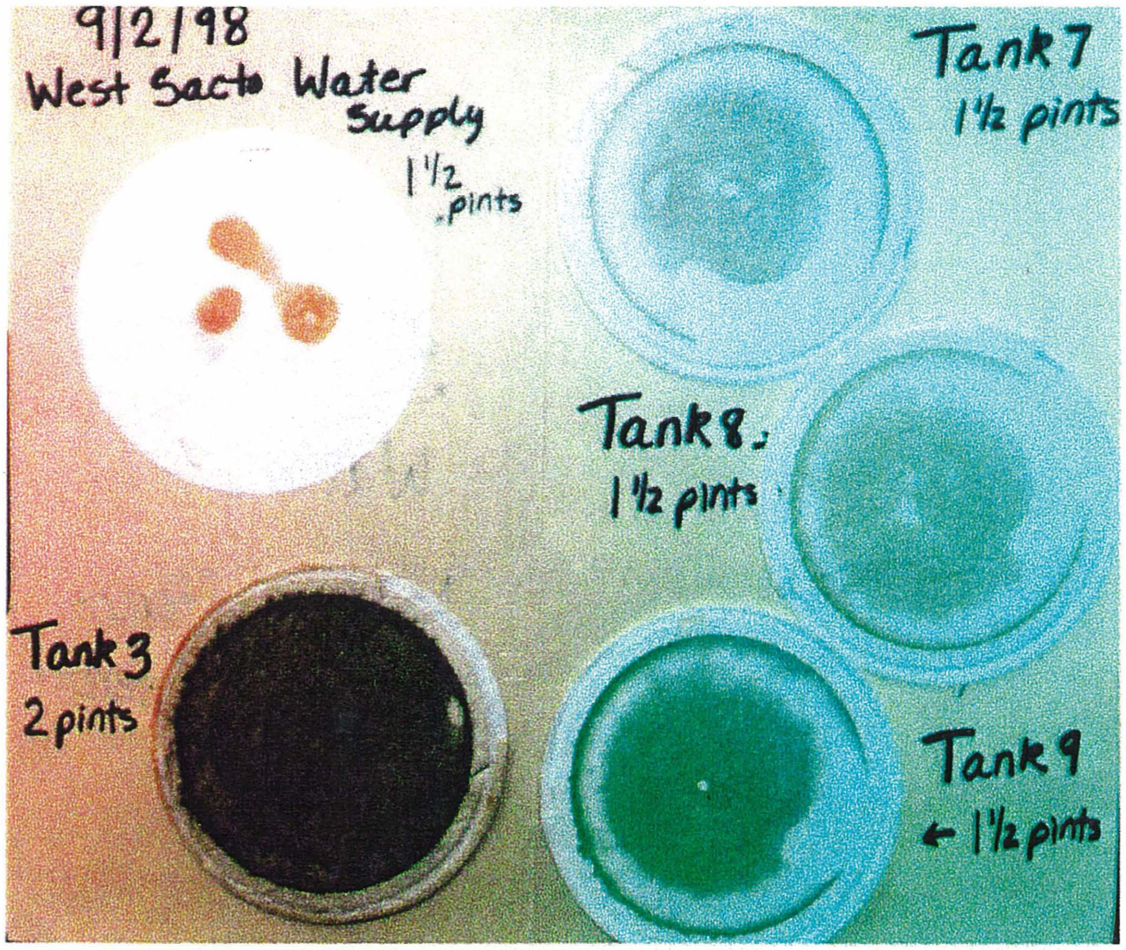
Future studies on algae should include measuring metabolic rates, such as changes in oxygen and carbon dioxide concentrations in the water. Productivity, defined as the rate of converting inorganic carbon to organic carbon, would be more useful as the results provide gross and net production in terms of amount of carbon fixed per cubic meter of water. Chlorophyll measurements provide crude estimates of the standing crop of algal biomass.

The pheophytin *a* concentrations increased over time as the algal blooms expired (Figure 15). Based on the color of the filtered algae samples, species identification, and biomass data, it appeared that different species or communities of algae predominated in each tank. Identified algae groups are shown in Table 5. Some blue-green algae are known to cause taste and odor problems and filter clogging in water supplies. Two green algae species, Oedogonium and Microspora stagnorum, found in the tanks have not been seen in Delta waters (M. Ngatia, pers. comm. 3/4/99). Results of biomass estimates and species identification of algae from the tanks during the study are in Appendix B.

The algal mats and suspended algae significantly affected water quality, including turbidity (Figure 16). High photosynthesis during daytime resulted in high dissolved oxygen concentrations and higher pH (Figures 17 and 18). As pH increases occur, carbonate (CO_3^{-2}) may coprecipitate with iron, calcium, and magnesium, thereby, lowering EC in the water column. Some tanks, mostly those with low water depth and with no water exchange, had lower DO readings due to high respiration. Some of the fluctuations between sampling events reflect sampling time in the early morning after nighttime respiration or in the later morning when photosynthesis becomes a dominant process.

Table 5. Algal Groups Identified in Tanks

Diatoms	Flagellates	Green Algae (non-filamentous)	Blue Green
Achnanthes Cyclotella Melosira Navicula Skeletonema Synedra	Chlamydomonas Cryptomonas Eudorina Euglena Gonium Gymnodinium Mallomonas Pandorina Unclassified Trachelomonas	Ankistrodesmus Chorella Dichthyoshae Microspora Oedogonium Oocystis Palmellococcus Scenedesmus Seleanastrum Ulothrix	Anabaena Oscillatoria



Filters (0.45 micron porosity) after 1.5 - 2 pints of surface water from the tanks and water supply were filtered. Rust particles, not algae, were in the main water supply. The color and amount of residue trapped by the filters varied among the tanks and indicated different dominant species of algae present.

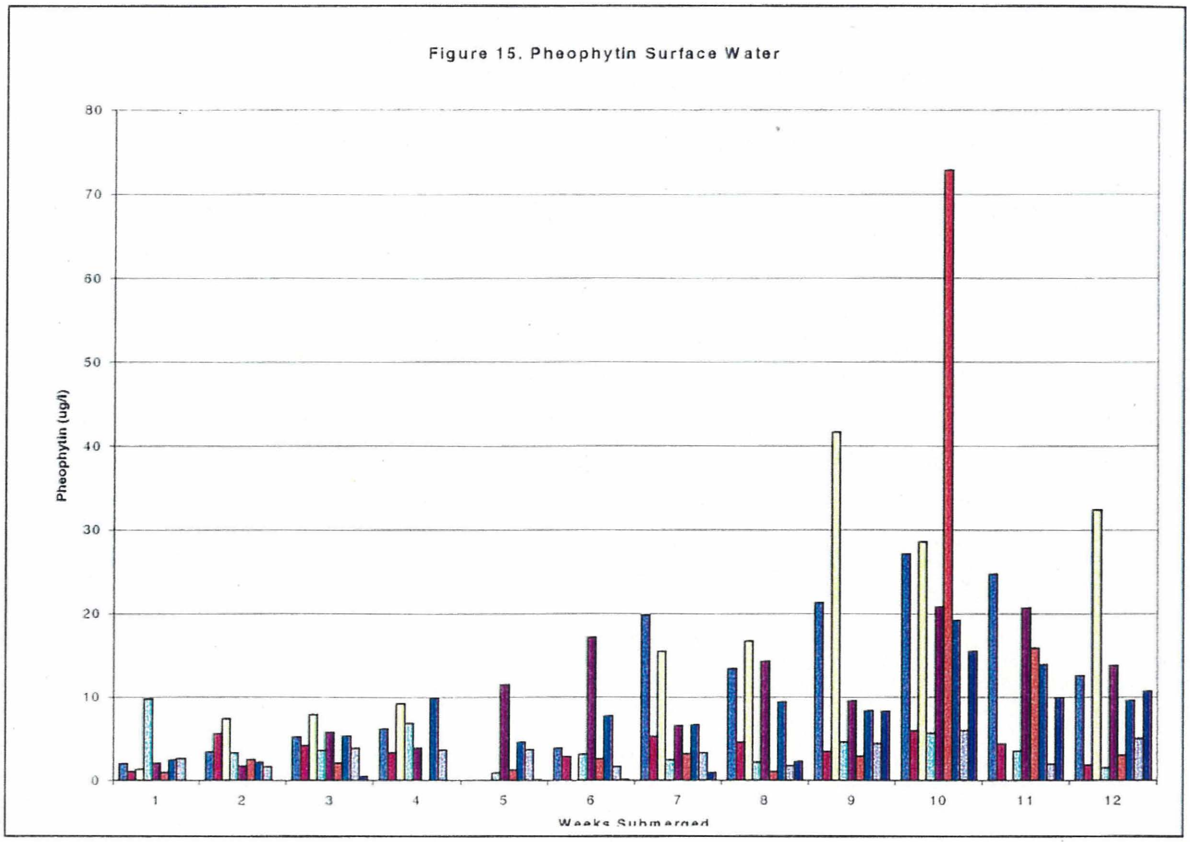


Figure 15. Pheophytin Surface Water
Pheophytin (ug/l)
Weeks Submerged

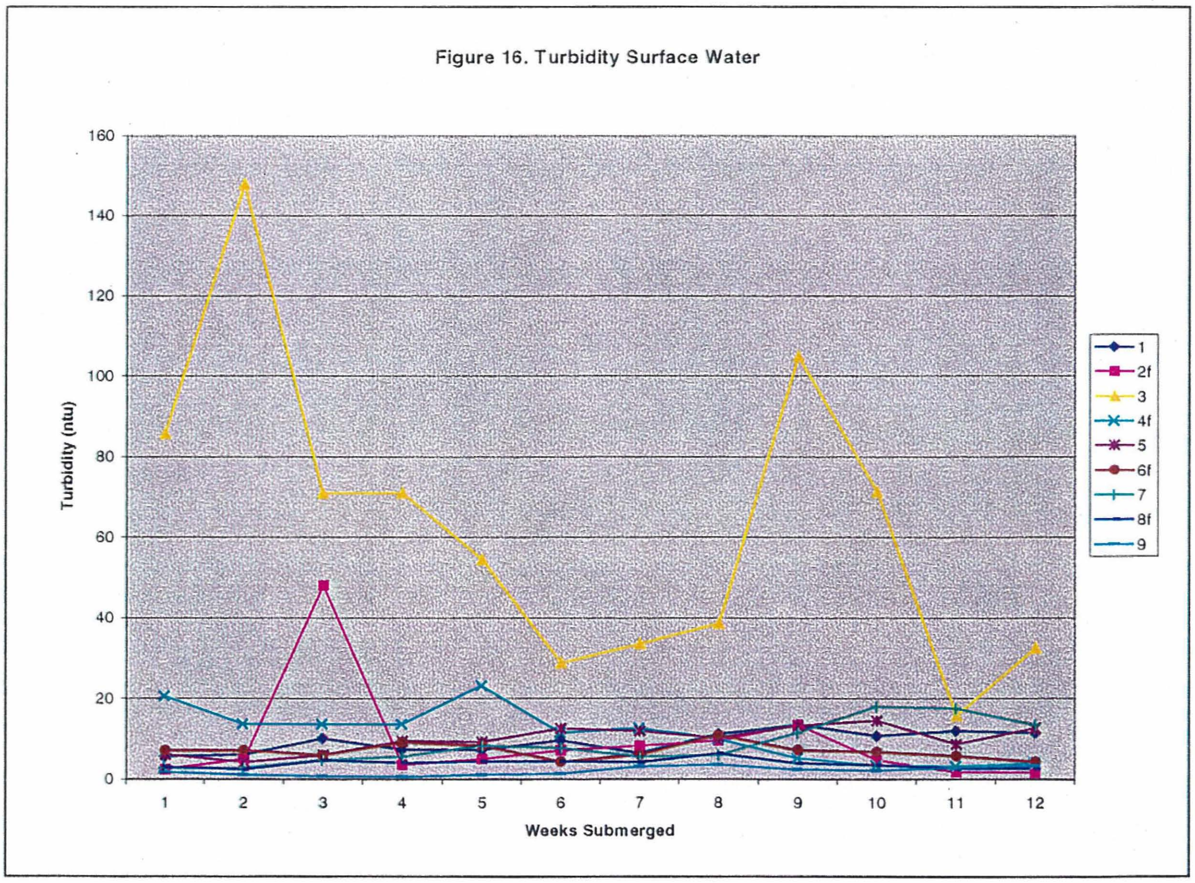


Figure 16. Turbidity Surface Water
Turbidity (ntu)
Weeks Submerged
1
2f
3
4f
5
6f
7
8f
9

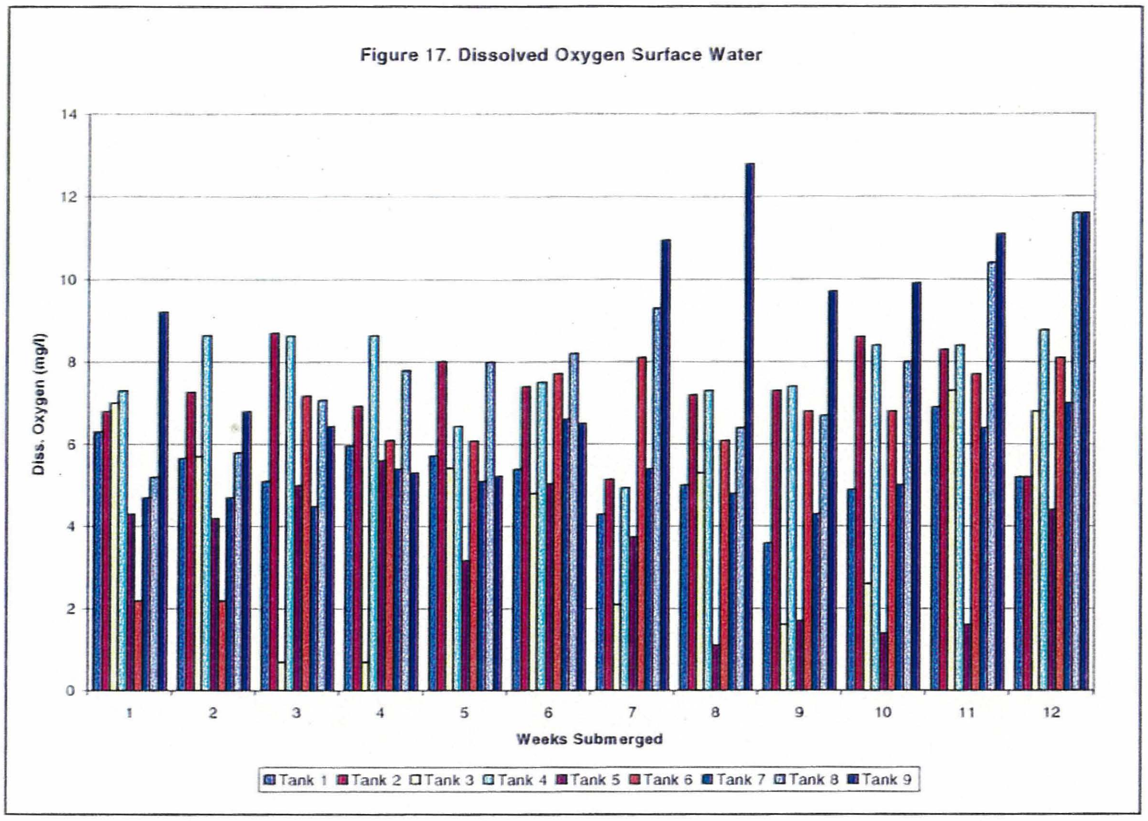


Figure 17. Dissolved Oxygen Surface Water
Diss. Oxygen (mg/l)
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
Weeks Submerged
Tank 1
Tank 2
Tank 3
Tank 4
Tank 5
Tank 6
Tank 7
Tank 8
Tank 9

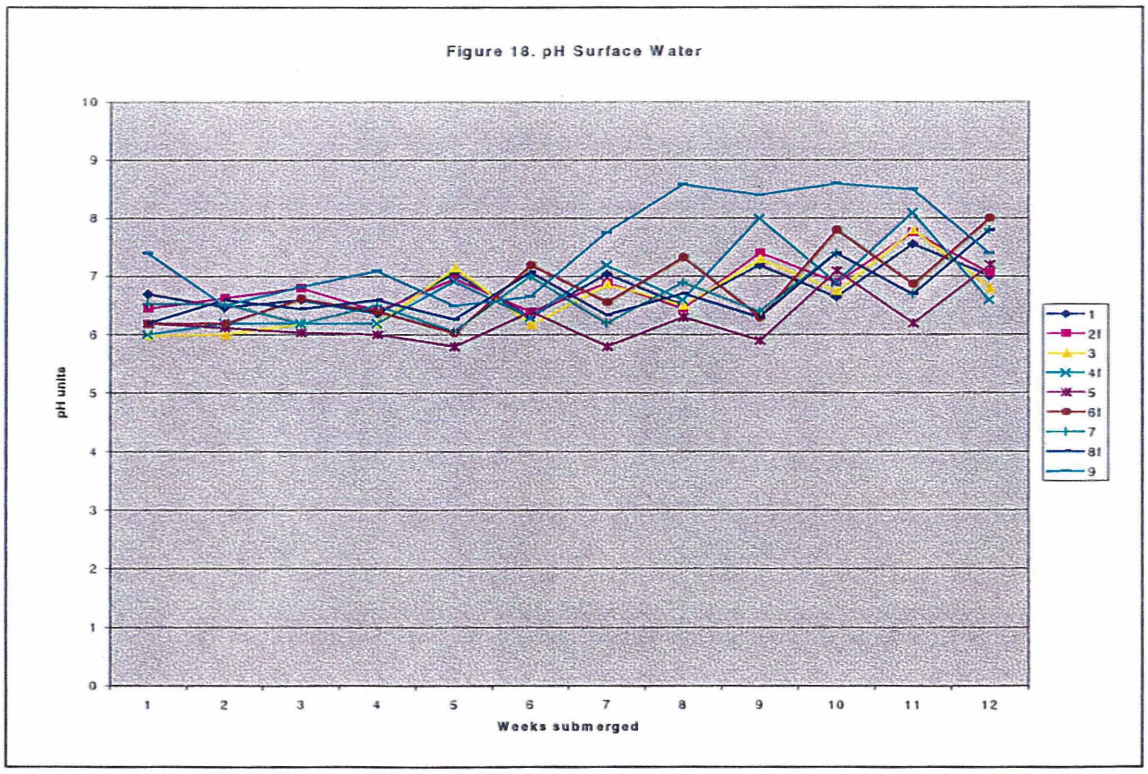


Figure 18. pH Surface Water
pH units
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
Weeks submerged
1
2f
3
4f
5
6f
7
8f
9

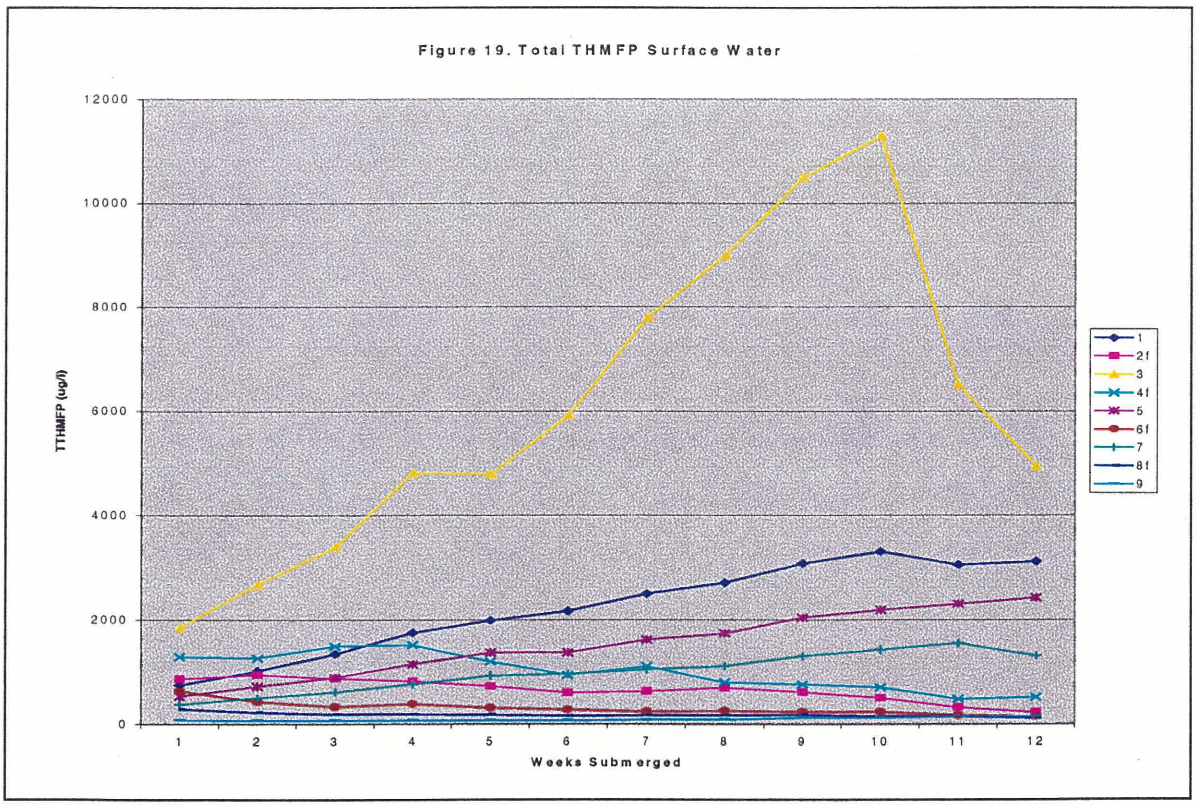
Cattail (*Typha* sp.) germinated and grew in shallow tanks 2f and 4f. Cattails need oxygen in the root zone to assimilate nutrients and water depths less than 4 feet. Apparently, the flow-through system provided sufficient oxygen at the soil-water interface to stimulate growth. No plants grew in tanks 1 and 3, their no water exchange counterparts. No plants grew in the other tanks, which had 7 feet of water.

The TTHMFP trends correlated strongly with the TOC trend (Figure 19). Tanks with flow had significantly lower TTHMFP concentrations than the group of tanks with no flow. By week 10, the TTHMFP in tanks 3,1,5, and 7 were respectively, 11300 µg/l, 3310 µg/l, 2190 µg/l, and 1430 µg/l. The TTHMFP in the tanks with continuous water exchange were 714 µg/l, 508 µg/l, 242 µg/l, and 158 µg/l in tanks 4f, 2f, 6f, and 8f, respectively. The materials test control tank (9) had a TTHMFP of 130 µg/l.

Nutrient levels showed that the impounded surface water would be classified as being eutrophic. The growth of algae confirmed that assessment. The nitrogen to organic nitrogen transformation by algae are shown in the TKN data (Figure 20). The lower nutrient concentrations in the tanks with continuous water exchange probably resulted from the combined effects of biological uptake and flushing out of the nutrients from the tanks over time. Other nutrient data are shown in Figures 21 – 23.

Cattail emerging from tank 2f.

Floating mat of algae in tank 6f.



Note: Water was added to tank 3 after samples were taken. Dilution affected subsequent tank 3 water quality.

Figure 20. TKN Surface Water

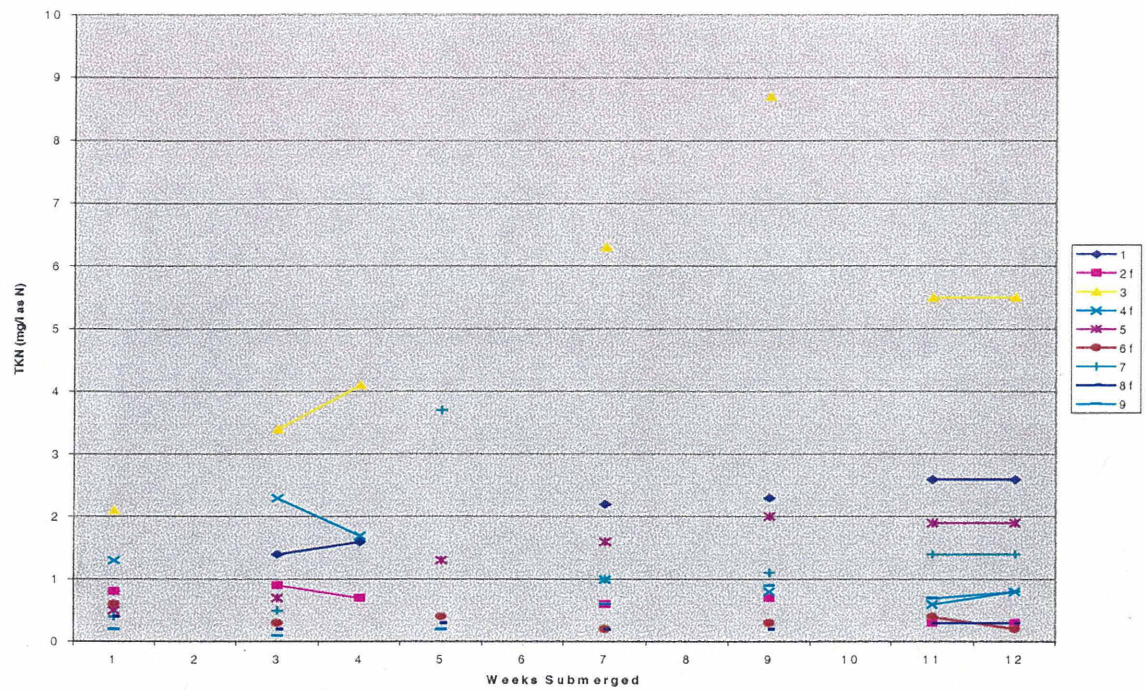
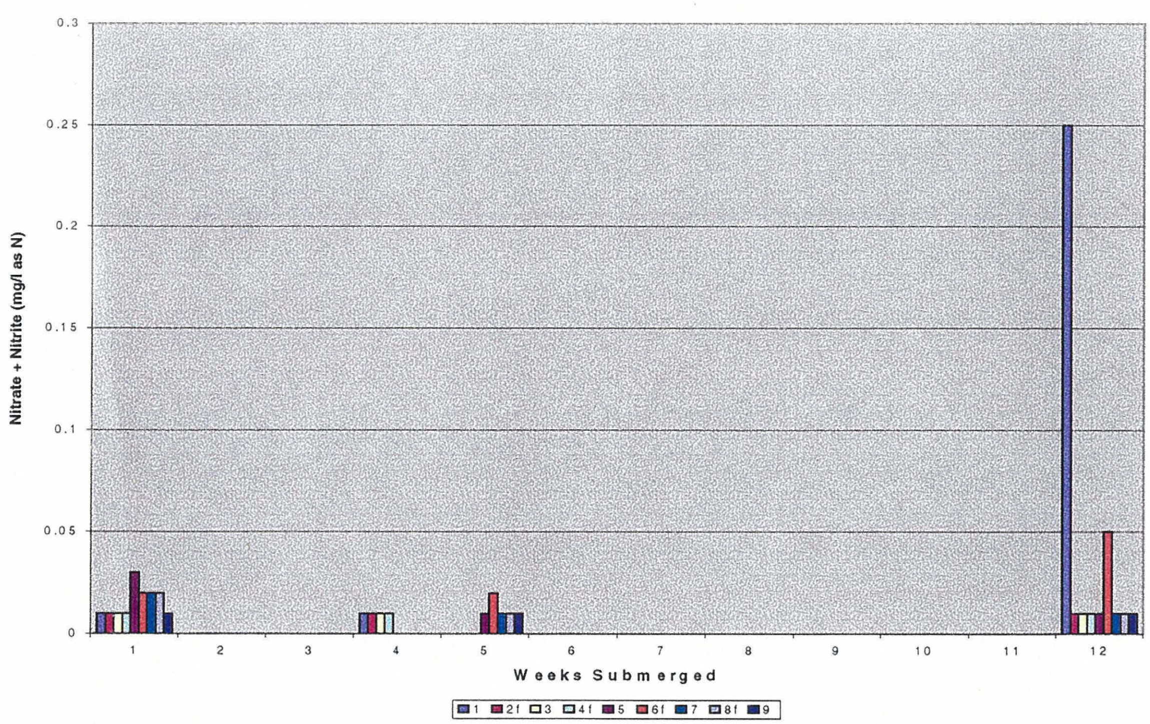
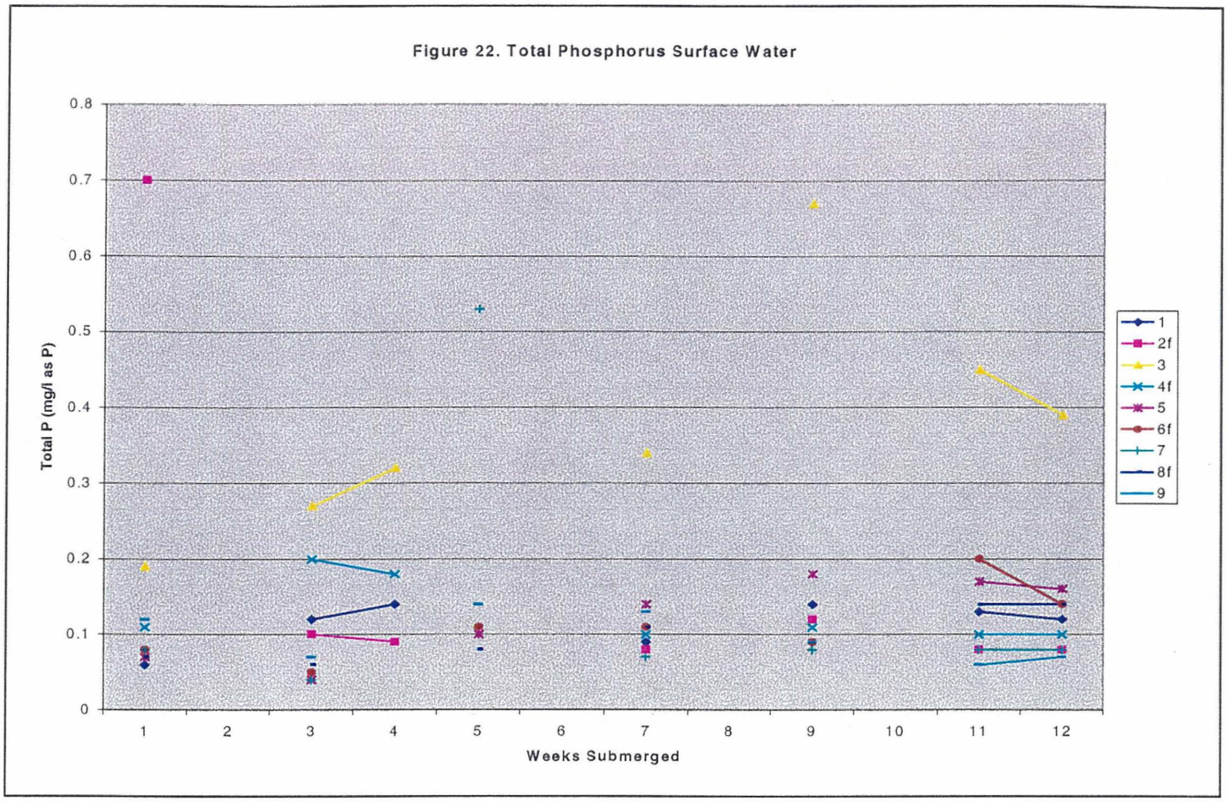
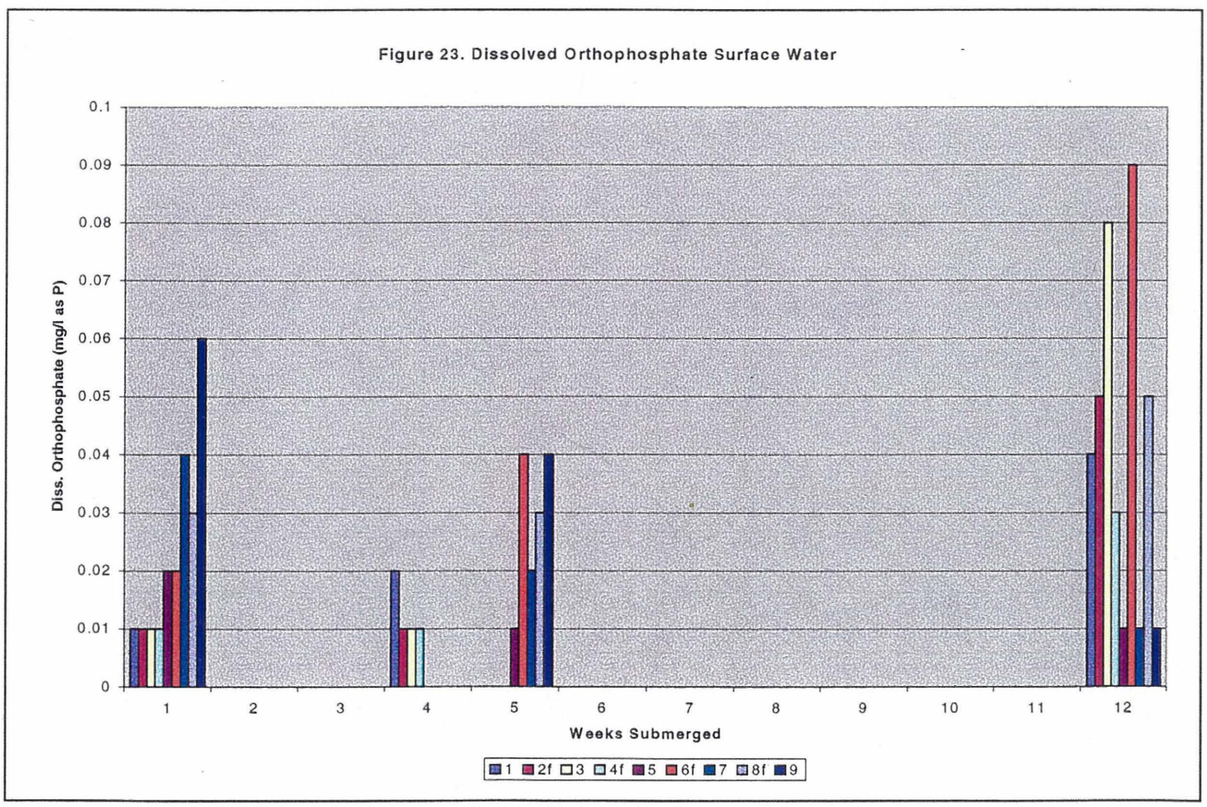


Figure 21. Nitrate + Nitrite Surface Water





Note: Water was added to tank 3 after the tenth week samples were taken. The dilution affected subsequent tank 3 water quality.



6. Factors and Interactions

The study methodology was based on a design of experiment protocol. Two levels of treatment for each of three factors were tested. Factor 1 was peat soil depth, factor 2 was water depth, and factor 3 was the water exchange rate. Each combination of conditions in the tanks represented different stages and possible conditions of a shallow wetland/water storage facility in operation. The 2^3 full-factorial experiment allowed us to examine eight effects and interactions. Standard procedures for a full-factorial designed experiment were followed (Box et. al. 1978, Frigon and Mathews, 1997). The data were rearranged into a standard order to compute values to assess the main effects from each of the three factors and interactions.

Summary tables of the experimental data and effects were prepared for TOC, DOC, TTHMFP, and EC results of the tenth week of the study. Charts of the main effects and interactions were plotted for each of the four water quality parameters to visually see the magnitude of the effects and to determine interaction (Appendix C). There are no interaction effects when lines representing any two main factors do not intersect. In such a case, the main effects are additive.

Further confirmation and interpretation of the results included examining the effects computations against normal order scores (Berthoeuex and Brown, 1994). In this study, there were no replicated measurements beyond those for laboratory QA purposes. Replication would have required a duplicate SMARTS facility with 9 tanks. Therefore, it was not possible to compute an estimate of the variance or to complete an ANOVA statistical procedure. Lacking a variance estimate, the normal order score (rankits) were plotted against the effects data. In this procedure, if the effects are random, i.e., caused by random measurement errors, the results may be expected to be normally distributed as with any other random variable. The statistical significance of the estimated effects can be evaluated by making the normal plot. If the effects represent only random variation, the values will plot as a straight line. If a factor has caused an effect to be greater than expected due to random error alone, then the effect will not fall on a straight line and are considered significant. Future repeated experiments would provide replication data for ANOVA determinations.

The results showed that at the end of ten weeks of inundation:

1. All three factors had major effects on the TOC, DOC, TTHMFP, and EC values in the surface water of the tanks.
2. Increasing peat soil depth from 1.5 ft. to 4 ft. increased the levels of the four water quality constituents.
3. Increasing water depth from 2 ft. to 7 ft. decreased the concentrations of the four parameters.
4. Increasing the water exchange rate from none to between 1 to 1.5 surface water volume exchanges per week over a ten-week period decreased the concentrations of the four parameters.

5. Interactions between the factors were not evident as shown in the interaction charts and normal plots.
6. The main effects are additive because interactions were not evident.

The combinations of high peat soil depth (mass), low water depth, and no continuous water exchange yielded the highest TOC, DOC, TTHMFP, and EC in the surface water. This condition was seen in tank 3. On the other hand, the tanks with the high water depth and continuous water exchange resulted in surface water with the lowest TOC, DOC, TTHMFP, and EC. This was seen in tanks 6f. and 8f.

There are subfactors within the tested main factor, peat, that would have contributed to the experimental results. Some of these include organic carbon content, age, and composition, compaction and porosity of the soil, mineral salt content, and nutrient concentrations. Subfactors for the other two factors that contributed to their results include the water quality composition of the supply and mixing within the tanks. ***For these reasons and the short duration of the test, the numerical effects results for each main factor and interaction should be interpreted qualitatively to assess the relative importance or strength of each factor as opposed to absolute values in terms of unit change in TOC, DOC, THMFP, or EC. Follow-up iterative experiments of longer duration are needed and are in progress at the SMARTS site.***

The computed main effects and interactions for TOC, DOC, TTHMFP, and EC after 10 weeks of submergence are summarized in the following table.

Factor	Peat depth	Water depth	Water exchange	Peat x water	Peat x exchange	Water x exchange	Peat x water x exchange
TOC	36.25	-40.55	-58.8	-28.8	-35.55	35.95	27.4
DOC	20.08	-28.45	-42.93	-15.78	-18.98	24.03	13.78
TTHMFP	2218	-2953	-4152	-1880	-2157	2542	1735
EC	90.75	-101.75	-113.75	-66.25	-78.25	87.25	51.75

The values indicate that magnitude of difference in the water quality parameter (e.g., TOC, EC) between the high treatment and low treatment effects calculation. For example, the computed main effect for peat depth for TOC indicated that the TOC concentration would be higher if the peat soil depth increased. The negative values for TOC from the factor water depth indicated reductions in TOC in the impounded surface water when water depth was increased. A similar conclusion can be made for the third factor, water exchange rate. The interaction effects were checked graphically for intersecting lines and confirmed through a normal probability plot. The normal plot chart (Figure 24) showed that the three factors tested were the main effects and the interaction results were random responses rather than significant ones.

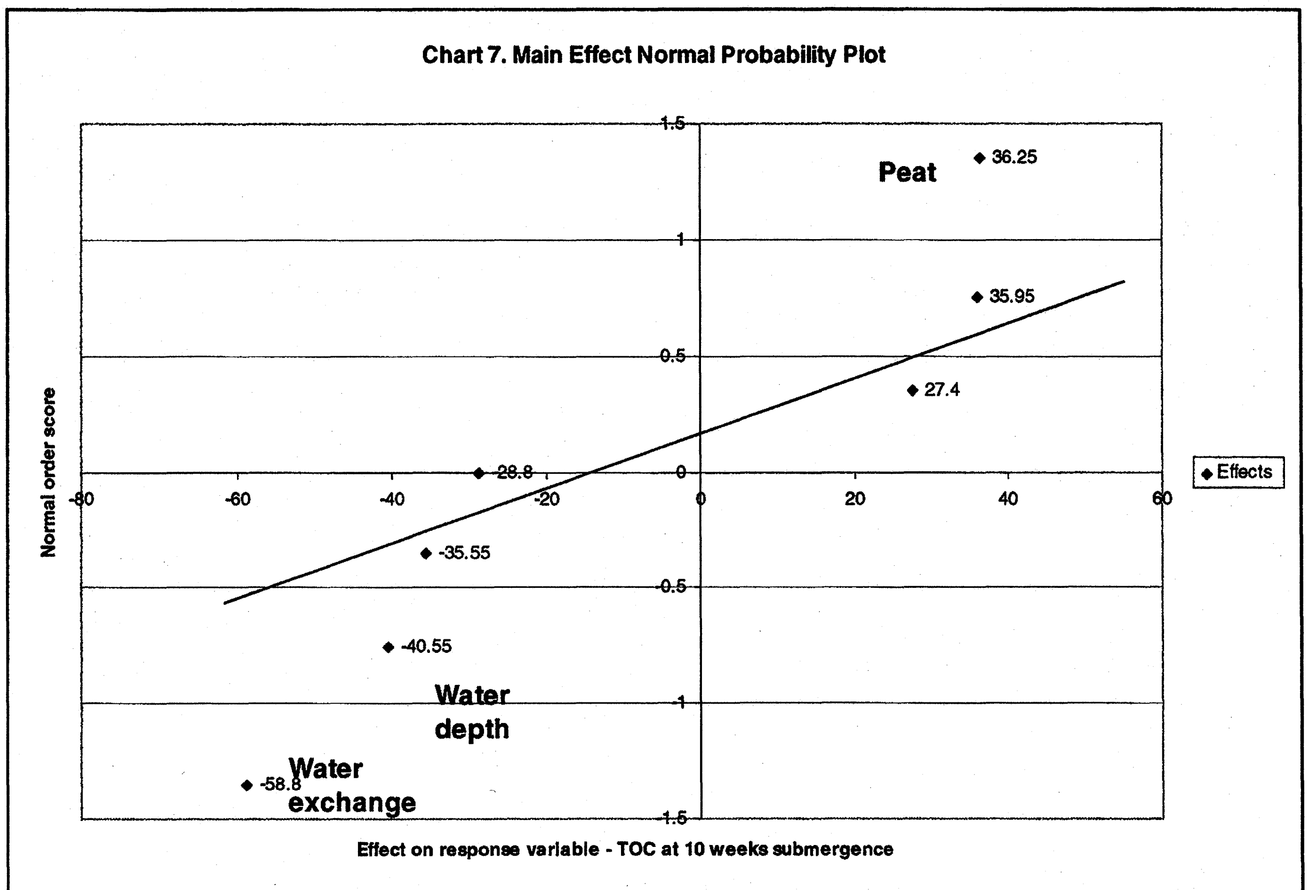


Figure 24. Main Effect Normal Probability Plot for TOC

The complete series of data summaries and effects tables and charts are in Appendix C. The magnitude of the three main factors suggests that all three had major effects on TOC concentration during the 12 week study. Similar results were seen for DOC, TTHMFP, and EC.

7. Rate of Water Quality Changes

The rates of TOC, DOC, and TTHMFP change per week in each tank up to the tenth sampling week for the surface water samples were computed. Linear regression lines and equations were computed with the R-squared values, which represent the goodness of the fitted lines. The data are summarized in the following table. TOC and DOC are in mg/l units, TTHMFP in µg/l, and x represents the weeks of submergence in the study. The higher R-squared values indicate a closer proximity of each weekly measurement to the regression line than the lower R-squared values that indicate some dispersion of the data. The regression plots are presented in Appendix D.

Surface Water TOC

Tank	Regression Equation	R-squared value	Week #1 TOC	Week #10 TOC
1	TOC = 3.1671x + 7.384	0.9761	11.4	38
2f	TOC = -0.4871x + 11.596	0.8609	10.1	6.2
3	TOC =15.886x + 0.8933	0.9835	26.2	166
4f	TOC = -1.1881x + 21.537	0.6275	17.5	8.3
5	TOC = 2.7676x + 2.924	0.9798	6.7	33.3
6f	TOC = -0.4386x + 6.8953	0.7144	8.2	3
7	TOC= 1.3605x + 3.7053	0.9567	5.1	17.7
8f	TOC = -0.0945x + 3.264	0.3994	3.9	2.3
9	TOC = 0.2626x + 0.8673	0.8689	1.2	3.8

Surface Water DOC

Tank	Regression Equation	R-squared value	Week #1 DOC	Week #10 DOC
1	DOC = 3.4036x + 5.16	0.9934	8	39.4
2f	DOC = -0.5472x + 11.379	0.8653	9.7	5.2
3	DOC = 11.974x + 10.853	0.9304	23.3	108
4f	DOC = -1.1042x + 19.913	0.7597	17.6	8.3
5	DOC = 2.1715x + 4.0867	0.9843	6.3	26
6f	DOC = -0.4242x + 6.3933	0.6472	6.1	2.8
7	DOC = 1.2655x + 3.46	0.9885	5	16.5
8f	DOC = -.01097x + 3.0333	0.5768	3.5	1.9
9	DOC = 0.1012x + 1.2733	0.7818	1.6	2.4

Surface Water TTHMFP

Tank	Regression Equation	R-squared value	Week #1 TTHMFP	Week #10 TTHMFP
1	TTHMFP = 282.25x + 513.13	0.9955	753	3310
2f	TTHMFP = -43.661x + 973.53	0.8417	872	508
3	TTHMFP = 1077.6x + 280.6	0.9781	1854	11300
4f	TTHMFP = -83.115x + 1573.3	0.7285	1300	714
5	TTHMFP = 179.91x + 376.2	0.9899	540	2190
6f	TTHMFP = -35194x + 534.07	0.7316	640	242
7	TTHMFP = 111.15x + 297.67	0.9847	382	1430
8f	TTHMFP = -9.9333x + 250.13	0.5994	290	158
9	TTHMFP = 5.3273x 64	0.6227	85	130

The goodness of fit of the data points to the regression line also confirms the validity of the data. The largest deviations or lower but acceptable R-squared values occurred in tanks 2f and 4f, which experienced flow interruptions in the first half of the study. The low R-squared value in tank 8f was due to little change in TOC, DOC, and TTHMFP during the study, probably because of the high dilution (7 ft. of water with 1.5 water volumes per week exchanged). Tank 9 changes in water quality are attributed to microbial activity and algae as this tank did not contain any peat soil. The highest rates of change based on the regression equations occurred in tank 3, which gained 15.9 mg/l of TOC per week, 11.9 mg/l DOC per week, and 1077 μg/l of TTHMFP per week. The data also supported the need to conduct a long-term experiment to determine seasonal changes in these rates of change. The rates appeared constant during the short study. This, perhaps, indicates a maximum rate of organic carbon production and degradation by microorganisms and algae. Cooler seasons might show significantly lower rates of change. Therefore, the above results should not be used to extrapolate annual mass loads of organic carbon or TTHMFP due to the short-term of this study and additional effects of evaporation, high primary productivity, and flow adjustment problems. We anticipate more meaningful data will come from Experiment #2.

8. Data Validation

Sample duplicates are environmental samples divided into two separate aliquots and analyzed independently to determine the repeatability of the analytical method. The relative percent difference (RPD) of the duplicate results must fall within established control limits. The results for the DWR Bryte Laboratory are summarized below. All of the sample duplicate analyses performed were reviewed. While most fell within the control limits, the highest RPDs occurred in analyses for particulate matter (e.g.,TOC, TKN, TP), which typically have the widest variation among all analytes and can be attributed to the collection of the samples or nonhomogeneous mixing rather than problems with precision. Internal laboratory quality control measures, such as matrix spikes and method blanks, were used in conjunction with RPDs of the duplicate samples to determine if the batch of samples had acceptable results. No samples were rejected on the basis of recoveries or RPDs outside of the limits. Data for the non-duplicate samples were used in the Results section of this report. The duplicate sample values are in Appendix B.

Drinking Water Pre-Treatment Constituents

Analyte	Acceptance RPD (%)	Method (EPA)	Total Analyses Reviewed	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
TOC	15	415.1(T)	13	1	8
DOC	15	415.1(D)	13	0	0
UVA	15	415.1(D)	13	1	8
Alkalinity	15	2320B	8	0	0
Bromide	15	300.0	8	0	0

Nutrient Constituents

Analyte	Acceptance RPD (%)	Method (EPA)	Total Analyses Reviewed	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
Ammonia	15	350.1	13	2	15
Nitrate + Nitrite	30	4500-NO3-F Modified	4	1	25
Total Kjeldahl Nitrogen	30	351.2	8	1	12.5
Ortho-phosphate	30	4500-P-F	5	1	20

Analyte	Acceptance RPD (%)	Method (EPA)	Total Analyses Reviewed	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
Total Phosphorus	30	365.4	8	1	12.5

Treated Drinking Water Constituents

Analyte	Acceptance RPD (%)	Method	Total Analyses Reviewed	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
Bromodichloromethane	20%	**	13	3	23
Bromoform	20%	**	13	0	0
Chloroform	20%	**	13	0	0
Dibromochloromethane	20%	**	13	0	0
Total THMFP	20%	**	13	0	0

**DWR THMFP Reactivity Test (7day)

Nutrient field blank samples were taken during each sampling event for sample collection quality control and assurance. Overall, RPD values did not indicate sample contamination or unacceptable data in the results.

Nutrient Field Blank Recoveries

Analyte	Reporting Limit	Total Analyses Reviewed	Recoveries Outside of Limits	Recoveries Outside of Limits (%)
Total Kjeldahl Nitrogen	0.1	13	0	0
Total Phosphorus	0.01	13	0	0
Dissolved Ammonia	0.01	13	1	8
Dissolved Nitrite + Nitrate	0.01	6	0	0
Ortho-phosphate	0.01	6	0	0

Data scatter or anomalies often occur in nature because of stochastic and deterministic processes. There is randomness in measurements and random errors occur from sampling and laboratory analyses. Duplicate samples and analyses for each sample are prohibitively expensive and unnecessary. The quality of results can be established to be consistently good through field and laboratory QC/QA procedures. In this study, at each sampling event, a blind duplicate was given to the lab from one of the tank samples chosen at random. The RPD and field blank results supplemented with internal QC and calibration of the lab instruments, give us some idea of the precision and acuracy of the measurements. Based on these data and the observed trends in the data, we are confident about the results, including concerns about taking single samples.

There were some consistent trends seen, such as in the TOC and DOC concentrations each week. For example, the order of tanks from the highest to the lowest TOC or DOC levels (Figures 10 and 11) were generally the same order with the exception occurring when flows adjustments in tanks 2f and 4f had to be corrected. The constant trend tells us that the same normal probability plots and conclusions would have been made if the experiment were terminated on other weeks.

The only data we found invalid due to a soil digestion method were the total P and bromide analyses for soil performed by BSK Laboratories.

Discussion

All three factors (peat soil depth, water depth, and water exchange rate) do affect the concentration of organic carbon and other water quality constituents in impounded waters overlying peat soil. Each of the eight test tank conditions simulated different combinations of the three factors during a short period of inundation.

The importance of dilution or high water depth in reducing high organic carbon and salt concentrations was seen. The worst water quality condition was seen in tank 3. This tank held four feet of peat under two feet of water with no continuous water exchange. TOC reached 166 mg/l at the end of ten weeks of submergence. The EC was 532 µS/cm, TTHMFP at 11,300 µg/l, and DOC at 108 mg/l. A massive algal mat grew in the tank and chlorophyll-*a* was up to 200 µg/l (equivalent to 13.4 mg/l TOC). These values far exceeded those reported for Delta island drain water samples except for a few collected during or after winter leaching of adjacent fields that were ponded to leach out salts (MWQI, 1994).

Peat soil was a high source of nutrients that helped stimulate algal growth in all the tanks. Mats of algae and gas ebullition from photosynthesis and respiration were seen. In some tanks, the algae mats floated and covered the entire surface and later sank to the bottom or became suspended as the algae colonies died or became dense and sank. This affected turbidity and probably some of the RPDs of the chlorophyll-*a* and nutrient analyses. The nutrient levels and chlorophyll-*a* were the highest in the impounded water in tank 3. Based on the surface water chlorophyll-*a* data, the Trophic State Index was 52 (Carlson, 1977). At this index, the conditions are described as the lower boundary of classical eutrophy for a lake with decreased transparency, anoxic hypolimnia during the summer, possible macrophyte problems, and iron and manganese and taste and odor problems if the water is used for drinking water (AWWARF, 1989). Others consider the conditions as hypereutrophic (Vollenweider and Kerekes, 1980).

The best water quality of a water storage condition was in tank 7, which held 1.5 ft. of peat under 7 ft. of water with no continuous water exchange. By the tenth week of submergence, the impounded water had 17.7 mg/l TOC, 16.5 mg/l DOC, 1430 µg/l TTHMFP, and EC at 174 µS/cm. Surface water in tank 5, which contained 4 ft. of peat under 7 ft. of water under no continuous water exchange, had 33.3 mg/l TOC, 26 mg/l DOC, 225 µS/cm EC, and 2,190 TTHMFP. In both cases, these concentrations, except for EC, are higher than those typically seen in the Delta channels and water export intakes.

Water exchange was another major factor that benefited water quality. The best conditions were seen in tanks 8f (4 ft. of peat) and 6f (1.5 ft. of peat), each with 7 ft. of water and a continuous water exchange of 1.5 surface water volume exchanges per week. The water quality were similar to conditions seen in the Delta channels.

Water quality in the tanks did not appear to stabilize until as early as the tenth week of the twelve-week experiment. For some tanks, in particular, those with no water exchange and flooded to a two-foot depth, water quality continued to degrade. The trends showed that future experiments should be longer than three months.

Water quality could have been worse as release mechanisms at the soil-water surface, such as bioturbation, wave action, and pore water circulation, were not studied or simulated. An in-depth study of the contribution of organic carbon from the seasonal production and decomposition of vegetation, macrophytes, algae, and phytoplankton, also needs to be studied. Future experiments have been planned to examine these sources.

Peat soil depth was a major factor and the water quality of the peat soil water showed that peat was a large reservoir of organic carbon with a high TTHMFP and high mineral (EC) and nutrient content. The concentrations were significantly greater than in the surface water. The concentrations were higher than those found in the subsurface of drained and ponded fields. The difference is attributed to the absence of a drainage mechanism or simulation in the SMARTS tanks that kept an anaerobic waterlogged environment. Concentrations are expected to decrease if the peat soil water was continuously or partially drained over time. There was evidence to support this assertion as a significant water quality change occurred in tank 1 between the fifth and ninth week sampling events. It would not be difficult to simulate drainage in the tanks in future experiments by opening the valves at the bottom of each tank.

The increases in TOC, DOC, UVA-254nm, nutrients, and THMFP over time in hydric soils were in agreement with known biogeochemical processes of wetlands. The results were similar to those reported in other studies of drainage and wetlands performed by the MWQI Program, the USGS, and researchers in Florida (Moore et. al., 1998; Vaithiyanathan and Richardson, 1998).

Conclusions

The objectives of the trial experiment were met. The power of a factorial experiment design allowed a number of questions to be addressed at once and in a statistically valid way. The design identified which of the tested controlling factors affected water quality in flooded peat soil environments. Technical problems (e.g., flow control, leakage) with the new SMARTS facility were resolved and corrective modifications to the tanks and start-up checklist have been made for future experiments. The study did provide information on the short-term water quality changes during the early stages of flooded peat soil environments during the summer months under shallow flooded conditions (~~4~~ 2 and 7 ft. deep). The results showed that the next iteration of studies should be longer and eliminate the effects of evaporation and algal blooms in the tanks. However, better designed experiments on the effects of rainfall, evaporation, and algal productivity should be pursued. The trial experiment has been a successful small step in planning future studies for the design, construction, and operation of shallow flooded wetlands that will have minimal impact on Delta water quality.

The results showed that all three factors had significant effects on water quality and that their effects were additive. All tanks with continuous water exchange had better water quality than those tanks with no continuous water exchange. Water quality was considered best in this study as a condition with low concentrations of TOC, DOC, TTHMFP, mineral salts, nutrients, and algae.

The best water quality resulted with the combination of high water depth (7 ft.) with continuous water exchange (1.5 surface water volume exchanges/wk). The worst condition occurred in a condition of high peat soil depth (4 ft.), low inundation depth (2 ft.), and with no continuous water exchange.

The results were compared against field studies conducted by others. There was good agreement between our simulated experiment and field studies. Minor differences could be attributed to containment of the subsurface water in our tanks. The studies of open fields and ponds had seepage and subsurface water movement (drainage) occurring.

The impounded surface waters were high in nutrients and algal blooms were seen in all tanks. Nutrient levels and chlorophyll-*a* concentrations were at those typical of eutrophic lakes. The most severe algal blooms were in the shallow flooded tanks with no continuous water exchange. The computed TOC from algae based on a standard chlorophyll-*a* to TOC conversion formula did not show algae to be the dominant source of organic carbon. Peat soil appeared to be the primary organic carbon source. However, the true contribution cannot be determined from the estimated biomass based on chlorophyll values. Future work needs to measure primary productivity, the rate at which inorganic carbon is converted to organic carbon.

The study provided information on which factors that should continue to be studied to predict the possible water quality conditions that might be seen from the immediate flooding and storage of water on a Delta peat soil wetland or island. Water quality changes were studied during the summer over a twelve-week period. Complete stabilization of some water quality parameters was uncertain and indicates the need for longer experiments to observe seasonal changes (e.g., overturn of organic matter) and to compute seasonal mass loads of organic carbon and other constituents. It is possible that other factors or some of the tested factors will become less important over time. For example, plant or algal production might surpass peat soil as a major controlling factor of organic carbon as a wetland matures.

The potential impact for impairing the drinking water quality of Delta water supplies is real but could be minimized. The study shows that: (1) the design, construction, and operation of a flooded peat environment in the Delta must at least consider the three factors that were studied, (2) long-term studies must be conducted, and (3) more intensive studies are needed to quantitatively predict water quality changes from different types of wetlands and management schemes.

A much improved second experiment, which is one-year long, is underway. Other factors to be studied should include plant biomass contributions of organic carbon. Factorial experiments follow an iterative process to identify the best conditions of main factors to produce desired results. In our case, the desired results are good water quality. Year 2000 experiments might include examining water quality changes from: (1) a deep flooded condition (30 – 45 ft. inundation), (2) sediment capping of peat soil, (3) wetland plant decay, (4) cycles of wet and dry periods in flooded wetlands, and (5) iterations of the past experiment to refine design and operational criteria for a wetland/water storage basin in the Delta.

The final task was to have the heavy wet peat soil flushed and vacuumed into a tank truck for disposal. This operation took two days to complete.

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APPENDICES

Appendix A

Modeling Delta Alternatives To Improve Drinking Water Quality
Work Plan (revision of March 1999)

MODELING DELTA ALTERNATIVES TO IMPROVE DRINKING WATER QUALITY WORK PLAN

Revision of March 1999

by

Marvin Jung

Original presented at MWQI Advisory Committee meeting of January 13, 1998

This is an outline of goals, tasks, and products that we plan to complete over the next two and a-half years with respect to identifying the best solutions for protecting and improving the drinking water quality of the delta.

We will review the historical drinking water quality of the delta to develop sets of input data for the Delta Water Treatment and Costs Model developed under the DWR/ Malcolm-Pirnie contract. We will test different scenarios of actions within the delta including the original set of 12+ proposed CalFed alternatives that might improve water quality and treatment. The scenarios include the following actions and in combination with each other:

1. reducing agricultural drainage volume by:
    a. conversion to fallow land
    b. conversion to flooded wetlands for soil subsidence control

2. reducing TOC concentrations in agricultural drainage by:
    a. treating drainwater by chemical flocculation prior to discharge
    b. reducing leaching frequency

3. relocating or adding intake and water storage sites
    a. out of delta storage
    b. in delta storage

4. blending water

5. reducing water residence time in the delta
    a. wider channels to increase flow
    b. deep flooded islands to increase flow and provide storage
    c. a separate canal

Technical briefings or workshops will be made before the MWQI Advisory Group as the work proceeds to each milestone. The Advisory Group will contribute to the program by providing guidance, suggestions, and review of the tasks. A series of technical summary reports will be prepared as consultant's reports to DWR. This will enable faster distribution of information to the MWQI Advisory Group. These reports, in turn, will be edited to become official DWR publications.

The following work plan describes the goals and products of modeling alternatives to improve the drinking water quality of delta water supplies. The tasks are grouped into three topics that were common themes in the original set of proposed CALFED list of delta alternatives. The topics for study are: (1) drainage control options, (2) designing wetlands and shallow water storage options, and (3) water supply intake options. These three topics will be studied concurrently. The results of the work will be used to prepare an Alternatives Assessment Report in year 2000.

Tasks

1. EXAMINING DRAINAGE CONTROL OPTIONS

Goal: Estimating Monthly DOC Loads from Delta Island Drainage

Proposed Report: Delta Island Drainage Estimates, 1954-55 vs. 1995
Completed: 1/98

We are comparing the 1995 and 1996 delta island drainage volume estimates computed by USGS for DWR in the Delta Island Water Use Study to the 1954-55 estimates in DWR Report Number 4 (1956). We are comparing the methodologies used, seasonal trends in estimated drainage volumes discharged, land use changes, computational assumptions, and water year hydrologies (e.g., rainfall). We will determine if there are significant differences between the annual and monthly estimates for the entire delta and subregions. A report titled "Delta Island Drainage Estimates, 1954-55 vs. 1995" will be prepared.

We will confer with the Delta Modeling Group on our analysis. Depending upon the results of our report, we may recommend a range of values to use for monthly drainage volume discharges rather than a single value such as an average. It is probable that there will be more than one set of monthly drainage volume numbers that will be recommended for use in the delta water quality and hydrology models.

Goal: Developing Drainage Reduction Options

Proposed Report: Candidate Regions in the Delta for Reduction of Organic Carbon Loads
Completed: 1/99

We will develop a set of island drainage reduction options. Organic carbon mass loads will be computed from drainage volume estimates and DOC concentration data collected under the MWQI Program since 1982. The historical and regional distribution of DOC has been studied and reported in previous MWQI reports. Mass load estimation work will begin in summer 1998. Delta areas with the highest organic carbon loads discharged into the delta channels will be identified.

Brown and Caldwell engineers completed a study for MWQI on the treatment of delta island drainage in 1997. The study found that a reduction of up to 60 percent could be achieved by conventional coagulation/flocculation processes. Fallowing land could be another option. The options will be developed on the basis of proximity to water supply intakes, dominant water circulation patterns in the delta, and size of DOC mass load from each island or subregion. A candidate list of islands or regions for organic carbon reduction will be developed.

The regional distribution of DOC in the delta was discussed in the MWQI Five-Year Report for January 1987 - December 1991 (DWR, 1994). Further analysis of MWQI data will be performed to develop expected monthly DOC values across the regions of the delta. These values will be used with monthly drainage volume estimates to compute monthly mass loads of DOC discharged from the delta islands. As with drainage volume estimates, we expect to generate more than one set of DOC concentration values to be used in the modeling work because of different water year classifications and conditions.

Goal: Model Runs of Drainage Control Options

Proposed Report: Water Quality Benefits from Controlling Delta Island Drainage
Completion Date: 6/99

The Delta Modeling Group will run predictive delta water quality models based on the Candidate Regions in the Delta for Reduction of Organic Carbon Loads report. The results will be used to help us develop other alternatives. For example, modeled results might show only slight improvement in water quality by reducing organic loads from three islands. Another model run that simulates more islands under treatment or intake relocation might be result in better water quality. There will be interaction between MWQI and Delta Modeling staff in refining possible alternatives.

If the bromate formation component of The Delta Water Treatment and Costs Model for THM Control, developed by Malcolm-Pirnie for MWQI, is available, the model will then be used to assess the cost of treating the resulting modeled water quality.

2. DESIGNING WETLANDS AND SHALLOW WATER STORAGE FACILITIES

Goal: Study of Factors Affecting Organic Carbon Availability from Flooded Environments (Wetlands and Water Storage)

Proposed Report: A Study of Factors Determining Short Term Water Quality Changes In Flooded Peat Soil Environments
Completion Date: 4/99

Initial experiments at the new SMARTS facility will be conducted to study the major factors that may affect DOC in waters overlying peat soil from wetlands creation and water storage on delta islands. The factors studied will be peat soil depth, inundation depth, and water exchange rates. This first experiment will run three months. The experimental protocol will be a full or partial factorial experimental design or response surface methodology. The information will be used to design and operate such projects with minimal impact on drinking water quality, specifically organic carbon concentrations. Iterations of the experiments are necessary and peat soil may be substituted with other soil types to study out-of-delta water storage options. Other follow-up experiments might examine TOC contributions from algae, decaying crop biomass, and wetland plants.

The results will be used to develop a computer model. Results of the SMARTS experiments may develop a model that relates the mass load of TOC to different water flow rates and water depth.

Goal: Assessing Organic Carbon Loads from Wetland and Water Storage Projects

Proposed Report: Model Runs of Proposed Wetland and Water Storage Projects in the Delta
Completion Date: 12/99

Computer model runs of hypothetical wetlands and water storage facilities in the delta (e.g., flooded islands) will be performed.

3. EXAMINING WATER SUPPLY INTAKE OPTIONS

Goal: Examine Water Quality at Proposed Water Supply Intakes

Proposed Report: Historical Data Report, MWQI 1982 - 1997
Completion Date: To be determined

Channel water quality data collected since 1982 will be summarized and interpreted. The report will describe the history, mission, and milestones of the Interagency Delta Health Aspects Monitoring Program and MWQI Program. Data analysis will primarily focus on the water quality parameters that are needed in the Delta Water Treatment and Costs Model for THM Control. The analysis will provide input data sets for the model runs.

Data needs will be identified and further data collection needs will be recommended to the MWQI Program for monitoring.

Goal: Assess Water Supply Intake Location Options

Proposed Report: Model Runs of Water Quality Benefits from Various Water Supply Intake Locations
Completion Date: To be determined

Computer model runs using historical and predicted water quality data for various potential water supply intakes in the delta will be performed.

4. ALTERNATIVES ASSESSMENT

Goal: Develop Candidate Delta Alternatives

Proposed Report: Summary Report of Candidate Water Transfer and Storage Alternatives to Improve Drinking Water Quality in the Delta
Completion Date: 2000 - 2001

Additional as needed SMARTS experiments, computer model runs, delta water quality monitoring, and refinements to delta alternative scenarios are expected to continue into 2000-2001. A final report will summarize the predicted water quality benefits from the computer model runs of the modeled delta alternatives and combinations of scenarios.

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Appendix B

Experiment Data

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

SAMPLING RESULTS FOR INITIAL RESEARCH:

Study of the Effects of Water Flow, Water Depth, and Peat Soil Depth on DOC Levels in Surface Water from Flooded Delta Island Soils

START-UP SAMPLE DATE: July 2, 1998

PEAT SOIL RESULTS

Analyses	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8	Tank 4, 7/16/98**
Soil Organic Matter (mg/Kg)	92000	62000	61000	76000	75000	64000	74000	74000	42000
Walkely-Black Method									
% Organic Matter	32	22	25	29	27	26	33	33	69
Nitrate (mg/Kg)	2	2.6	4.2	4.2	2.6	2.6	2.4	2.2	<1.0
Total Nitrogen (mg/Kg)	5200	4500	3500	4000	4300	4000	4100	4300	2400
Total Kjeldahl Nitrogen (mg/Kg)	5200	4500	3500	4000	4300	4000	4100	4300	2400
Total Phosphorus (mg/Kg)	~~0.49~~	~~2.4~~	~~0.52~~	~~0.42~~	~~2.0~~	~~0.69~~	~~2.7~~	~~2.2~~	~~<3.0~~
Bromide (mg/Kg)	~~<2.5~~	~~<2.5~~	~~<2.5~~	~~<2.5~~	~~<2.5~~	~~<2.5~~	~~<2.5~~	~~<2.5~~	~~<2.5~~

WATER SUPPLY RESULTS

Analyses	Value	Field Measurements	
DOC (mg/L)	1.08	Temperature	21.6
		EC	131
UVA (mg/L)	0.014	DO	8.42
		pH	6.99
Alkalinity (mg/L)	38	Turbidity	8
Bromide (mg/L)	<0.1		

NOTES: **Additional peat sample taken from Tank 4 after it had been inadvertently drained on 7/15/98. Sample was taken before additional water was added to the tank.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS) EXPERIMENT 1 - July 15, 1998 through October 7, 1998												
SURFACE WATER												
WEEK 1												
	Sample Date: July 22, 1998					Sample Date: July 15, 1998					Duplicate	QA/QC
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4		TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 3	RPD
TOC (mg/L)	8.7	10.1	26.2	17.5		6.7	8.2	5.1	3.9	1.2	22	17.43
DOC (mg/L)	8.0	9.7	23.3	17.6		6.3	8.1	5.0	3.5	1.6	23.5	0.85
UVA (mg/L)	0.415	0.478	1.17	0.922		0.261	0.333	0.183	0.127	0.02	1.15	1.72
Specific Absorbanc	5.19	4.93	5.02	5.24		4.14	4.11	3.66	3.63	1.25	4.89	2.58
Alkalinity (mg/L)	33	35	43	45		34	37	37	38	41	43	0.00
Ammonia (mg/L)	<0.1	<.01	0.02	<.01		0.01	<.01	<.01	<.01	<.01	0.02	0.00
Bromide (mg/L)	0.036	0.042	0.082	0.081		0.016	0.027	0.018	0.012	<.01	0.087	5.92
Nitrate + Nitrite (mg	<.01	<.01	<.01	<.01		0.03	0.02	0.02	0.02	0.01	<.01	0.00
Total Kjeldahl Nitrog	0.8	0.8	2.1	1.3		0.5	0.6	0.4	0.4	0.2	2.5	17.39
Dis. Orthophosphat	<.01	<.01	<.01	0.01		0.02	0.02	0.04	0.03	0.06	0.01	#VALUE!
Total Phosphorus (m	0.06	0.7	0.19	0.11		0.07	0.08	0.08	0.07	0.12	0.24	23.26
Bromodichlorometh	23	32	54	<50		<20	<20	12	<10	6	59	8.85
Bromoform (ug/L)	<20	<20	<50	<50		<20	<20	<10	<10	<1	<50	
Chloroform (ug/L)	730	840	1800	1300		540	640	370	290	79	1800	0.00
Dibromochlorometh	<20	<20	<50	<50		<20	<20	<10	<10	<1	<50	
TOTAL THMFP	753	872	1854	1300		540	640	382	290	85	1859	0.27
Chlorophyll-a	12.4	8.94	31.1	28.1		4.03	2.24	1.64	2.56	5.72	26.5	15.97
Pheophytin-a	2.05	1.13	1.38	9.8		2.1	0.981	2.51	2.65	<0.01	2	36.69
Field Measurements:												
Temperature	21.6	21.3	20.6	20.7		26	26.8	27.1	27.2	28	20.6	
EC	148	153	157	180		138	135	136	142	135	157	
DO	6.3	6.8	7.0	7.3		4.3	2.19	4.7	5.2	9.2	7.0	
pH	6.7	6.45	5.99	6.0		6.19	6.19	6.53	6.2	7.4	5.99	
Turbidity	5.59	2.48	85.8	20.6		6.02	7.1	2.8	3.11	1.75	85.8	

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4.
Correct data for Tanks 6 and 8. Flow started to Tanks 2,4,6,and 8 on 7/16/98.

NOTE: Tank #3 had been drained 7//2/98 after developing a leak; refilled on 7/8/98.

NOTE: The pumps were started in all tanks on 7/9/98. All tanks were topped off with fresh water on 7//14/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

SURFACE WATER

WEEK 2

	Sample Date: July 29, 1998				Sample Date: July 22, 1998					Duplicate	QA/QC
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK *	RPD
TOC (mg/L)	11.4	10.6	32.6	15.5	8.6	5.4	5.9	2.8	1.9		
DOC (mg/L)	11.3	10.4	31	14.8	8.4	5.0	5.9	2.8	1.5		
UVA (mg/L)	0.603	0.517	1.64	0.783	0.42	0.223	0.286	0.092	0.024		
Specific Absorbance Ca	5.3363	4.9712	5.29032	5.2905	5	4.46	4.8475	3.2857	1.6	#DIV/0!	
Alkalinity (mg/L)	35	43	56	54							
Ammonia (mg/L)	0.03	<.01	0.02	<.01	<.01	0.02	<.01	<.01	<.01		
Bromide (mg/L)											
Nitrate + Nitrite (mg/L)											
Total Kjeldahl Nitrogen (											
Dis. Orthophosphate (m											
Total Phosphorus (mg/L											
Bromodichloromethane (	35	47	81	72	24	24	<20	11	6		
Bromoform (ug/L)	<30	<20	<62.5	<30	<20	<10	<20	<10	<1		
Chloroform (ug/L)	990	900	2600	1200	700	410	510	220	74		
Dibromochloromethane	<30	<20	<6.25	<30	<20	<10	<20	<10	<1		
TOTAL THMFP (ug/	1025	947	2681	1272	724	434	510	231	80	0	
Chlorophyll-a	24.6	16.4	71.1	33.5	11	5.63	24.9	8.63	3.17		
Pheophytin-a	3.42	5.62	7.38	3.33	1.75	2.53	2.2	1.67	<.01		
Field Measurements:											
Temperature	21.4	21.3	20.4	20.2	22.4	26.8	27.1	23.4	25.3		
EC	160	158	190	188	149	135	136	147	137		
DO	5.65	7.27	5.7	8.64	4.2	2.19	4.7	5.8	6.8		
pH	6.47	6.63	6.01	6.2	6.12	6.19	6.53	6.6	6.5		
Turbidity	6.14	5.04	148	13.6	4.21	7.1	2.8	2.41	1.2		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tanks 4. Reflects correct results for Tanks 6 and 8.

NOTE: Flow had been started to Tanks 2,4,6,and8 on 7/16/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

SURFACE WATER

WEEK 3

	Sample Date: August 5, 1998				Sample Date: July 29, 1998					Duplicate	QA/QC
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 5	RPD
TOC (mg/L)	15.7	11.2	46.3	22.3	10.8	4.2	7.5	2.54	1.6	10.9	0.92
DOC (mg/L)	15.1	10.7	42.6	19.1	9.91	3.8	6.9	2.23	1.41	10.2	2.88
UVA (mg/L)	0.813	0.532	2.15	0.944	0.523	0.169	0.365	0.075	0.021	0.524	0.19
Specific Absorbance Ca	5.38	4.97	5.05	4.94	5.28	4.45	5.31	3.36	1.49	5.14	2.69
Alkalinity (mg/L)	37	41	75	66	39	47	39	45	42	39	0.00
Ammonia (mg/L)	0.04	<.01	0.02	<.01	<.01	<.01	<.01	<.01	<.01	<.01	0.00
Bromide (mg/L)											
Nitrate + Nitrite (mg/L)											
Total Kjeldahl Nitrogen (m	1.4	0.9	3.4	2.3	0.7	0.3	0.5	0.2	0.1	0.7	0.00
Dis. Orthophosphate (mg											
Total Phosphorus (mg/L)	0.12	0.1	0.27	0.2	0.04	0.05	0.04	0.06	0.07	0.02	66.67
Bromodichloromethane (u	55	45	100	100	40	18	25	12	<10	41	2.47
Bromoform (ug/L)	<30	<30	<100	<50	<20	<10	<20	<10	<10	<20	0.00
Chloroform (ug/L)	1300	840	3300	1400	860	320	600	180	81	900	4.55
Dibromochloromethane (	<30	<20	<100	<50	<20	<10	<20	<10	<10	<20	0.00
TOTAL THMFP (ug/L	1355	885	3400	1500	900	338	625	192	81	941	4.45
Chlorophyll-a	82.1	31.8	174	26.4	14.4	9.57	7.14	7.14	2.7		200.00
Pheophytin-a	5.24	4.23	7.91	3.6	5.78	2.11	5.33	3.86	0.515		200.00
Field Measurements:											
Temperature	29.4	29.1	28.2	20.2	23.0	23.3	24.0	23.6	25.6	23	
EC	167	160	228	188	160	156	146	154	140	160	
DO	5.1	8.7	0.7	8.64	4.99	7.18	4.48	7.08	6.44	4.99	
pH	6.6	6.8	6.2	6.2	6.04	6.62	6.2	6.45	6.82	6.04	
Turbidity	10	48	71	13.6	5.97	5.97	4.72	4.64	0.82	5.97	

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

SURFACE WATER WEEK 4	Sample Date: August 12, 1998				Sample Date: August 5, 1998					Duplicate	QA/QC
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 5	RPD
TOC (mg/L)	21.5	9.9	64.9	20.9	13.6	5.2	8.9	2.8	1.7	14	2.90
DOC (mg/L)	20.2	9.6	59.2	18.4	12.8	4.6	8.5	2.4	1.68	12.5	2.37
UVA (mg/L)	0.975	0.43	2.78	0.859	0.634	0.231	0.447	0.071	0.021	0.603	5.01
Specific Absorbance Ca	4.83	4.48	4.70	4.67	4.95	5.02	5.26	2.96	1.25	4.82	2.64
Alkalinity (mg/L)	41	43	92	66							
Ammonia (mg/L)	0.02	<.01	0.02	<.01	<.01	0.11	<.01	<.01	<.01	<.01	
Bromide (mg/L)	0.058	0.071	0.224	0.171	0.086	0.025	0.064	0.016	<.01	0.08	7.23
Nitrate + Nitrite (mg/L)	<.01	<.01	<.01	<.01							
Total Kjeldahl Nitrogen (m	1.6	0.7	4.1	1.7							
Dis. Orthophosphate (mg	0.02	0.01	<.01	<.01							
Total Phosphorus (mg/L)	0.14	0.09	0.32	0.18							
Bromodichloromethane (u	60	58	220	120	47	25	47	15	6	31	41.03
Bromoform (ug/L)	<50	<20	<125	<50	<30	<10	<20	<10	<1	<30	
Chloroform (ug/L)	1700	770	4600	1400	1100	370	720	180	73	1100	0.00
Dibromochloromethane (	<50	<20	<125	<50	<30	<10	<20	<10	<1	<30	
TOTAL THMFP (ug/L	1760	828	4820	1520	1147	395	767	195	79	1131	1.40
Chlorophyll-a	89.3	24.3	208	69	39.6	36.6	8.96	15.2	2.65	39.1	1.27
Pheophytin-a	6.19	3.32	9.19	6.84	3.88	<.01	9.9	3.65	<.01	3.7	4.75
Field Measurements:											
Temperature	26.6	27.0	28.2	20.2	30.5	30.5	30.6	30.4	31.5	30.5	
EC	178	159	228	188	167	158	147	156	141	167	
DO	5.96	6.92	0.7	8.64	5.6	6.1	5.4	7.8	5.3	5.6	
pH	6.37	6.41	6.2	6.2	6.0	6.4	6.5	6.6	7.1	6.0	
Turbidity	7.36	3.58	71	13.6	9.54	9.06	5.61	4.1	0.79	9.54	

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

SURFACE WATER

WEEK 5

	Sample Date: August 19, 1998				Sample Date: August 12, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 7	RPD	Supply
TOC (mg/L)	24.73	9.57	76.65	16.53	17	5	12.7	2.7	1.95	12.6	0.79	1.5
DOC (mg/L)	23.3	8.99	72.7	15.02	15.9	3.8	10.5	2.4	1.78	10.5	0.00	1.3
UVA (mg/L)	1.14	0.39	3.05	0.673	0.769	0.162	0.522	0.066	0.022	0.521	0.19	0.016
Specific Absorbance Calc	4.89	4.34	4.20	4.48	4.84	4.26	4.97	2.75	1.24	4.96	0.19	
Alkalinity (mg/L)					49	45	41	66	44	40	2.47	44
Ammonia (mg/L)	<.01	<.01	0.03	<.01	0.01	0.03	<.01	<.01	<.01	<.01		
Bromide (mg/L)					0.113	0.025	0.083	0.017	<.01	0.081	2.44	<.01
Nitrate + Nitrite (mg/L)					<.01	0.02	<.01	<.01	<.01	<.01		
Total Kjeldahl Nitrogen (m					1.3	0.4	3.7	0.3	0.2	2.8	27.69	
Dis. Orthophosphate (mg					<.01	0.04	0.02	0.03	0.04	0.01	66.67	
Total Phosphorus (mg/L)					0.1	0.11	0.53	0.08	0.14	0.43	20.83	
Bromodichloromethane (u	92	50	<250	110	76	22	59	15	6	44	29.13	
Bromoform (ug/L)	<50	<20	<250	<30	<50	<10	<30	<10	<1	<30		
Chloroform (ug/L)	1900	680	4800	1100	1300	300	880	170	74	850	3.47	
Dibromochloromethane (u	<50	<20	<250	<30	<50	<10	<30	<10	<1	<30		
TOTAL THMFP (ug/L)	1992	730	4800	1210	1376	322	939	185	80	894	4.91	
Chlorophyll-a	121	41.9	172	13.1	36.8	5.2	14	10.5	6.34	14.3	2.12	
Pheophytin-a	<.01	<.01	<.01	0.916	11.5	1.24	4.65	3.72	0.793	6.96	39.79	
Field Measurements:												
Temperature	19.6	19.8	18.3	18.5	27.5	27.8	27.5	27.6	28.6	27.5		
EC	193	163	267	193	180	155	152	155	145	152		
DO	5.71	8.01	5.42	6.43	3.18	6.08	5.1	8.0	5.22	5.1		
pH	7.06	6.96	7.15	6.92	5.8	6.03	6.06	6.27	6.5	6.1		
Turbidity	7.26	5.09	54.5	23.2	9.17	8.27	8.35	4.42	1.13	8.35		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

NOTE: Added 61 gallons fresh water to Tank 7 on 8/12/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 6

	Sample Date: August 26, 1998				Sample Date: August 19, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 8	RPD	Supply
TOC (mg/L)	26.6	8.2	86	12.2	19.56	3.83	12.08	2.6	2.01	2.59	0.39	1.6
DOC (mg/L)	25.0	7.5	82.6	11.5	17.66	3.4	11.0	2.31	1.69	2.2	4.88	1.3
UVA (mg/L)	1.28	0.34	3.73	0.526	0.762	0.145	0.542	0.06	0.022	0.061	1.65	0.018
Specific Absorbance Calc	5.12	4.5	4.5	4.6	4.3	4.3	4.9	2.6	1.3	2.8	6.53	1.4
Alkalinity (mg/L)												47
Ammonia (mg/L)	0.01	<.01	0.04	<.01	0.02	<.01	<.01	<.01	<.01	<.01	0.00	
Bromide (mg/L)												<0.1
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (m												
Dis. Orthophosphate (mg												
Total Phosphorus (mg/L)												
Bromodichloromethane (u	170	41	420	98	80	17	64	13	7	11	16.67	
Bromoform (ug/L)	<50	<20	<250	<30	<50	<10	<30	<10	<1	<10		
Chloroform (ug/L)	2000	570	5500	850	1300	270	900	150	70	150	0.00	
Dibromochloromethane (u	<50	<20	<250	<30	<50	<10	<30	<10	<1	<10		
TOTAL THMFP (ug/L	2170	611	5920	948	1380	287	964	163	77	161	1.23	
Chlorophyll-a	63.9	26.5	103	14.3	52.1	12.1	12.7	10.9	8.67	10.3	5.66	
Pheophytin-a	3.9	2.88	<.01	3.12	17.2	2.64	7.76	1.72	0.13	1.49	14.33	
Field Measurements:												
Temperature	19.5	19.6	17.4	18.2	20.6	21.0	21.1	21.3	22.7	21.3		
EC	204	165	304	185	185	150	152	152	144	152		
DO	5.4	7.4	4.80	7.5	5.04	7.71	6.61	8.2	6.5	8.2		
pH	6.31	6.4	6.18	6.30	6.4	7.2	7.0	7.08	6.66	7.08		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 7

PARAMETER	Sample Date: September 2, 1998				Sample Date: August 26, 1998					Duplicate	QA/QC	Water
	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 6	RPD	Supply
TOC (mg/L)	31.3	7.9	108	15.1	21.1	3.2	12.1	2.3	2.4	3.2	0	1.8
DOC (mg/L)	29.8	7.3	98.7	13.8	19.6	2.8	11.5	2.2	1.7	2.7	3.64	1.4
UVA (mg/L)	1.51	0.333	4.66	0.649	0.958	0.116	0.578	0.062	0.026	0.115	0.87	0.019
Specific Absorbance Calc	5.07	4.56	4.72	4.70	4.89	4.14	5.03	2.82	1.53	4.26	2.77	1.36
Alkalinity (mg/L)	62	53	133	70	59	48	45	48	47	48	0	52
Ammonia (mg/L)	0.26	0.04	0.04	0.01	0.01	0.01	0.07	0.02	<.01	0.01	0	
Bromide (mg/L)												<.01
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (m	2.2	0.6	6.3	1.0	1.6	0.2	1	0.2	0.6	0.2	0	
Dis. Orthophosphate (mg												
Total Phosphorus (mg/L)	0.09	0.08	0.34	0.1	0.14	0.11	0.07	0.11	0.13	0.11	0	
Bromodichloromethane (u	200	55	800	120	120	16	73	15	8	14	13.33	
Bromoform (ug/L)	<100	<20	<250	<30	<50	<10	<30	<10	<1	<10		
Chloroform (ug/L)	2300	580	7000	1000	1500	230	980	160	85	210	9.09	
Dibromochloromethane (u	<100	<20	<250	<30	<50	<10	<30	<10	<1	<10		
TOTAL THMFP (ug/L	2500	635	7800	1120	1620	246	1053	175	93	224	9.36	
Chlorophyll-*a*	63.4	20.8	232	7.74	40.5	2.37	8.06	10.4	28.4	3.69	43.56	
Pheophytin-*a*	19.8	5.28	15.5	2.51	6.59	3.23	6.7	3.36	0.969	1.53	71.43	
Field Measurements:												
Temperature	25.3	25.9	22.2	25.4	21.1	21.8	21.8	21.5	22.9	21.8		25.4
EC	216	173	203	208	193	153	157	154	146	153		158
DO	4.3	5.14	2.10	4.95	3.74	8.1	5.4	9.3	10.95	8.1		5.9
pH	7.04	6.89	6.87	7.20	5.8	6.56	6.2	6.34	7.76	6.56		6.7
Turbidity	6.47	8.2	33.6	12.6	12	6.18	5.65	4.19	3.13	6.18		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

NOTE: Added 61 gallons fresh water to Tank 7 on 8/19/98.

NOTE: Added 49.5 gallons fresh water to Tank 1 and 23.1 gallons to Tank 7 on 9/2/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 8

	Sample Date: September 9, 1998				Sample Date: September 2, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 8	RPD	Supply
TOC (mg/L)	30.8	8.1	124	11.7	24.6	3.6	14.2	2.9	3.3	2.9	0	1.8
DOC (mg/L)	31.9	7.6	114	10.7	19.4	3.3	13.6	2.3	2.2	2.3	0	1.4
UVA (mg/L)	1.72	0.351	5.68	0.489	1.1	0.147	0.629	0.073	0.031	0.073	0	0.019
Specific Absorbance Calc	5.39	4.62	4.98	4.57	5.67	4.45	4.63	3.17	1.41	3.17	0	1.36
Alkalinity (mg/L)												52
Ammonia (mg/L)	0.24	0.02	0.05	<.01	0.02	0.02	0.04	0.02	<.01	<.01		
Bromide (mg/L)	0.31	0.06	1.28	0.12	0.17	0.02	0.12	0.02	<.01	0.02	0	<.01
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Bromodichloromethane (u	210	61	1000	80	140	21	110	17	7	17	0	
Bromoform (ug/L)	<100	<20	<250	<30	<50	<10	<30	<10	<1	<10		
Chloroform (ug/L)	2500	640	8000	730	1600	240	1000	160	91	160	0	
Dibromochloromethane (u	<100	<20	<250	<30	<50	<10	<30	<10	<1	<10		
TOTAL THMFP (ug/L	2710	701	9000	810	1740	261	1110	177	98	177	0	
Chlorophyll-*a*	32.1	36.5	219	14.9	71.8	1.23	18.4	10.5	83.5	11.6	9.9548	
Pheophytin-*a*	13.4	4.6	16.7	2.19	14.3	1.11	9.42	1.82	2.3	2.56	33.79	
Field Measurements:												
Temperature	20.6	20.4	17.3	18.7	27.0	27.0	27.2	27.1	27.9	27.1		25.4
EC	220	175	383	187	212	164	168	163	150	163		158
DO	5.0	7.2	5.30	7.3	1.1	6.1	4.8	6.4	12.8	6.4		5.9
pH	6.5	6.45	6.5	6.60	6.3	7.33	6.9	6.71	8.58	6.71		6.7
Turbidity	11.1	9.49	38.7	9.92	10.1	10.9	5.96	6.38	3.59	6.38		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

NOTE: Added 49.5 gallons fresh water to Tank 1 and 23.1 gallons to Tank 7 on 9/2/98.

NOTE: Flow to Tank 2 was at 80mL/min when checked, adjusted to 114 mL/min.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 9

	Sample Date: September 17, 1998				Sample Date: September 9, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 4*	RPD	Supply
TOC (mg/L)	36.6	7.4	152	10	26.2	3.2	15.7	2.6	3.2	11.9	17.35	1.3
DOC (mg/L)	34.8	6.7	135	9.2	24.3	3.0	14.8	2.3	2.3	10.9	16.92	1.2
UVA (mg/L)	1.93	0.319	6.54	0.414	1.24	0.122	0.741	0.069	0.039	0.485	15.80	0.017
Specific Absorbance Ca	5.55	4.76	4.84	4.50	5.10	4.07	5.01	3.00	1.70	4.45	1.13	1.42
Alkalinity (mg/L)	66	56	190	64	68	50	48	49	53			48
Ammonia (mg/L)	0.04	0.01	0.08	0.03	<.01	<.01	0.02	<.01	0.04	<.01		
Bromide (mg/L)												<.01
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (m	2.3	0.7	8.7	0.8	2.0	0.3	1.1	0.2	0.9			
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.14	0.12	0.67	0.11	0.18	0.09	0.08	0.09	0.09			
Bromodichloromethane (u	280	57	1200	78	140	20	110	19	<10	98	22.73	
Bromoform (ug/L)	<100	<20	<357	<20	<50	<10	<30	<10	<10	<30		
Chloroform (ug/L)	2800	560	9300	690	1900	220	1200	170	130	830	18.42	
Dibromochloromethane (	<100	<20	<357	<20	<50	<10	<30	<10	<10	<30		
TOTAL THMFP (ug/L	3080	617	10500	768	2040	240	1310	189	130	928	18.87	
Chlorophyll-*a*	29.7	2.55	205	8.12	87.1	8.2	24.1	11.8	62.6	9.57	16.39	
Pheophytin-*a*	21.3	3.46	41.7	4.59	9.53	2.91	8.36	4.45	8.3	6.91	40.35	
Field Measurements:												
Temperature	20.0	20.4	16.8	19.1	22.8	22.6	23.2	23.3	24.7	18.7		21.3
EC	236	179	483	206	218	159	169	160	151	187		150
DO	3.6	7.3	1.60	7.4	1.7	6.8	4.3	6.7	9.7	7.3		
pH	7.2	7.4	7.3	8.0	5.9	6.3	6.4	6.3	8.4	6.6		6.5
Turbidity	13.4	13.4	105	5.3	13.2	7.21	11.5	3.87	2.39	9.92		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

NOTE: Flow to Tank 2 adjusted to 120 mL/min. on 9/17/98.

*Duplicate is Tank 4, sampled on WEEK 8, September 9, 1998, not the date as shown.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 10

	Sample Date: September 23, 1998				Sample Date: September 17, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 8	RPD	Supply
TOC (mg/L)	38	6.2	166	8.3	33.3	3.0	17.7	2.3	3.8	2.4	4.26	1.6
DOC (mg/L)	39.4	5.2	108	8.3	26.0	2.8	16.5	1.9	2.4	1.9	0.00	1.3
UVA (mg/L)	1.91	0.219	7.89	0.345	1.3	0.105	0.824	0.058	0.041	0.056	3.51	0.021
Specific Absorbance Ca	4.85	4.21	7.31	4.16	5.00	3.75	4.99	3.05	1.71	2.95	3.51	1.62
Alkalinity (mg/L)												59
Ammonia (mg/L)	0.02	<.01	0.05	<.01	<.01	<.01	<.01	<.01	<.01	0.02		
Bromide (mg/L)					0.25	0.02	0.18	0.02	0.01	0.02	0.00	<.01
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Bromodichloromethane (u	310	48	1400	74	190	22	130	18	<10	18	0.00	
Bromoform (ug/L)	<100	<10	<250	<24	<50	<10	<50	<10	<10	<10		
Chloroform (ug/L)	3000	460	9900	640	2000	220	1300	140	130	140	0.00	
Dibromochloromethane (	<100	<10	<250	<20	<50	<10	<50	<10	<10	<10		
TOTAL THMFP (ug/L	3310	508	11300	714	2190	242	1430	158	130	158	0.00	
Chlorophyll-*a*	16.6	3.29	64.7	23.1	79	121	35.7	10.8	38.4	9.57	12.08	
Pheophytin-*a*	27.1	5.98	28.6	5.67	20.8	72.9	19.2	6.02	15.5	6.91	13.77	
Field Measurements:												
Temperature	18.1	18.5	15.6	17.7	21.7	21.8	22.8	22.2	23.3	22.2		22.6
EC	245	174	532	201	225	174	174	172	150	172		182
DO	4.9	8.6	2.60	8.4	1.4	6.8	5.0	8.0	9.9	8.0		
pH	6.65	6.9	6.75	6.9	7.1	7.8	7.4	7.4	8.6	7.4		
Turbidity	10.8	4.75	71.4	3.5	14.5	6.82	18	3.51	2.27	3.51		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

NOTE: Tank 2 needed new hose on pump.

NOTE: Added 60 gallons fresh water to Tank 3 and 54 gallons to Tank 7 on 9/23/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 11

	Sample Date: September 30, 1998				Sample Date: September 23, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 8	RPD	Supply
TOC (mg/L)	41.5	4.1	99.1	6.3	28.9	2.5	18.7	2.3	3.7	2.5	8.33	1.6
DOC (mg/L)	39.8	3.6	92.4	5.8	27.2	2.1	18.5	2.0	2.5	2.1	4.88	1.2
UVA (mg/L)	2.06	0.146	4.42	0.24	1.39	0.078	0.859	0.049	0.042	0.07	35.29	0.021
Specific Absorbance Calc	5.18	4.06	4.78	4.14	5.11	3.71	4.64	2.45	1.68	3.33	30.55	1.75
Alkalinity (mg/L)	74	52	125	55	78	72	51	54	54	51	5.71	44
Ammonia (mg/L)	0.02	0.02	0.03	<.01	0.01	0.02	<.01	<.01	<.01	<.01		
Bromide (mg/L)												<.01
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (m	2.6	0.3	5.5	0.6	1.9	0.4	1.4	0.3	0.7	0.2	40.00	
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.13	0.08	0.45	0.1	0.17	0.2	0.08	0.14	0.06	0.18	25.00	
Bromodichloromethane (u	260	32	810	46	210	13	150	16	<10	14	13.33	
Bromoform (ug/L)	<100	<10	<250	<20	<100	<10	<50	<10	<10	<10		
Chloroform (ug/L)	2800	300	5700	450	2100	160	1400	140	160	160	13.33	
Dibromochloromethane (u	<100	<10	<250	<20	<100	<10	<50	<10	<10	<10		
TOTAL THMFP (ug/L)	3060	332	6510	496	2310	173	1550	156	160	174	10.91	
Chlorophyll-*a*	31.8	3.74	177	8.97	54.4	18.6	21	70.8	76.4	85.9	19.27	
Pheophytin-*a*	24.7	4.38	<.01	3.56	20.7	1.98	13.9	15.9	9.93	28.3	56.11	
Field Measurements:												
Temperature	16.7	16.9	15.8	16.5	19.1	19.5	18.9	19.6	20.0	19.6		20.3
EC	248	161	340	167	229	177	177	165	154	165		134
DO	6.9	8.3	7.30	8.4	1.6	7.7	6.4	10.4	11.1	10.4		
pH	7.56	7.76	7.79	8.1	6.2	6.87	6.7	6.7	8.5	6.7		
Turbidity	12	1.8	15.8	3.3	8.66	5.7	17.6	2.6	2.77	2.6		

NOTE: Reflects modified sampling schedule due to dumping of water from surface waters of Tank 4. Reflects correct results for Tanks 6 and 8.

NOTE: Added 60 gallons fresh water to Tank 3 and 54 gallons to Tank 7 on 9/23/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Surface Water

WEEK 12

	Sample Date: October 7, 1998				Sample Date: September 30, 1998					Duplicate	QA/QC	Water
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	TANK 8	RPD	Supply
TOC (mg/L)	41.2	3.6	90.15	7.6	28.5	2.0	17.3	2.4	4.4	2.6	8	1.2
DOC (mg/L)	40.3	3.6	87.9	7.4	26.4	1.9	16.0	1.8	2.4	1.7	5.71	1.1
UVA (mg/L)	2.08	0.133	4.34	0.338	1.32	0.054	0.756	0.038	0.042	0.038	0.00	0.018
Specific Absorbance Calc	5.16	3.69	4.94	4.57	5.00	2.84	4.73	2.11	1.75	2.24	5.71	1.64
Alkalinity (mg/L)	75	51	137	59	77	46	51	50	58	51	1.98	47
Ammonia (mg/L)	0.07	<0.01	0.04	0.01	<.01	<.01	<.01	<.01	<.01	<.01		
Bromide (mg/L)	0.49	0.03	1.26	0.07	0.28	<.01	0.17	0.01	<.01	0.01	0.00	<.01
Nitrate + Nitrite (mg/L)	0.25	<0.01	<0.01	<0.01	<.01	0.05	<.01	<.01	<.01	<.01		
Total Kjeldahl Nitrogen (m	2.6	0.3	5.5	0.8	1.9	0.2	1.4	0.3	0.8	0.3	0.00	
Dis. Orthophosphate (mg	0.04	0.05	0.08	0.03	<.01	0.09	<.01	0.05	<.01	0.06	18.18	
Total Phosphorus (mg/L)	0.12	0.08	0.39	0.1	0.16	0.14	0.08	0.14	0.07	0.13	7.41	
Bromodichloromethane (u	320	22	640	44	220	10	120	12	<10	12	0.00	
Bromoform (ug/L)	<100	<10	<250	<20	<50	<10	<50	<10	<10	<10		
Chloroform (ug/L)	2800	210	4300	480	2200	140	1200	110	150	110	0.00	
Dibromochloromethane (u	<100	<10	<250	<20	<50	<10	<50	<10	<10	<10		
TOTAL THMFP (ug/L	3120	232	4940	524	2420	150	1320	122	150	122	0.00	
Chlorophyll-*a*	3.16	1.45	70.3	14.4	67.8	3.24	21.2	26.4	88.5	19.5	30.07	
Pheophytin-*a*	12.6	1.83	32.4	1.54	13.8	3.06	9.64	5.07	10.7	13.3	89.60	
Field Measurements:												
Temperature	16.6	16.9	15.7	16.7	17.3	17.4	17.4	17.7	17.6	17.7		17.7
EC	256	152	354	171	226	148	177	154	153	154		145
DO	5.2	5.2	6.80	8.77	4.4	8.1	7	11.6	11.6	11.6		
pH	7.01	7.06	6.8	6.6	7.2	8.0	7.8	7.8	7.4	7.8		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Peat Water

1st MONTH

	Sample dates: July 15* and July 22**, 1998								duplicate	QA/QC	duplicate
PARAMETER	TANK 1*	TANK 2**	TANK 3**	TANK 4*	TANK 5*	TANK 6**	TANK 7*	TANK 8**	TANK 1 *	RPD*	TANK 3 **
TOC (mg/L)	162	232	221	144	137	220	154	196	165	1.83	220
DOC (mg/L)	158	205	222	145	143	226	155	208	157	0.63	228
UVA (mg/L)	7.78	11.6	11.5	5.8	5.78	12.4	6.76	10.9	7.72	0.77	11.6
Specific Absorbance Ca	4.92	5.66	5.18	4.00	4.04	5.49	4.36	5.24	4.92	0.14	5.09
Alkalinity (mg/L)	92	158	167	53	48	191	51	123	92	0.00	172
Ammonia (mg/L)	2.4	4.6	5.1	4.7	3.7	6.3	3.8	5.1	2.5	4.08	4.9
Bromide (mg/L)	0.528	1.32	1.76	0.775	0.635	1.69	0.151	1.4	0.562	6.24	1.65
Nitrate + Nitrite (mg/L)	0.02	<0.1	<0.1	0.02	0.02	<0.1	0.02	<0.1	0.21		<0.1
Total Kjeldahl Nitrogen (	12	16	17	14	14	18	14	17	13	8.00	17
Dis. Orthophosphate (m	0.22	0.38	0.4	0.18	0.11	0.38	0.16	0.28	0.21	4.65	0.4
Total Phosphorus (mg/L	0.74	0.91	0.7	0.68	0.6	0.74	0.59	0.7	0.84	12.66	0.7
Bromodichloromethane (	410	730	1000	540	440	1000	560	830	360	12.99	1000
Bromoform (ug/L)	<360	<500	<500	<360	<360	<500	<360	<500	<360		<500
Chloroform (ug/L)	9800	12000	12000	8100	7400	12000	8600	10000	9700	1.03	12000
Dibromochloromethane	<360	<500	<500	<360	<360	<500	<360	<500	<360		<500
TOTAL THMFP (ug/	10210	12730	13000	8640	7840	13000	9160	10830	10060	1.48	13000
Field Measurements:											
Temperature	26.1	23.1	22.7	26.6	26.1	22.9	27.2	22.8	26.1		22.7
EC	842	986	1480	2060	1931	1830	1890	2140	842		1480
DO	0.8	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	<1.0	<1.0		<1.0
pH	5.28	5.4	5.6	5.13	5.18	5.48	5.1	5.32	5.28		5.6

NOTES: Modified sampling schedule has peat tanks sampled once per month, 4 tanks sampled on alternate weeks, due to high turbidity and cost of filtering.
Data for Tanks 6 and 8 are accurate.

NOTES: Tank 3 was drained because of a leak on 7/2/98. It was repaired and refilled on 7/8/98. All tanks were topped off with fresh water on 7/8/98 and again on 7/14/98. The pumps in all tanks were started on 7/9/98.

NOTES: On 7/15/98, Tank 4 was drained instead of Tank 1 after discovery of an error in filling the tanks. Tank 4 was refilled with water and a sediment sample taken and sent to BSK. Tanks 1 and 2 were drained to the 2-foot level.

NOTES: Flow was started to Tanks 2,4,6,and 8 on 7/16/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Peat Water

2nd MONTH

Sample dates: August 12* and August 19, 1998**

PARAMETER	TANK 1*	TANK 2**	TANK 3**	TANK 4*	TANK 5*	TANK 6**	TANK 7*	TANK 8**
TOC (mg/L)	287	309.1	299.55	290	282	369.24	358	358.77
DOC (mg/L)	287	300.75	273.2	282	271	338.3	336	341
UVA (mg/L)	15.6	14.9	14.7	15.3	15.6	16.6	18.2	17.1
Specific Absorbance Calc.	5.44	4.95	5.38	5.43	5.76	4.91	5.42	5.01
Alkalinity (mg/L)	344	370	379	333	330	427	424	485
Ammonia (mg/L)	8.5	9.7	9.4	9.4	10.3	12	10.9	11
Bromide (mg/L)	2.41	3.43	3.46	3.52	3.82	4.88	4.33	4.75
Nitrate + Nitrite (mg/L)	0.02			0.02	0.01		<.01	
Total Kjeldahl Nitrogen (mg/L)	22	22	21	24	25	26	28	26
Dis. Orthophosphate (mg/L)	0.58	0.49	0.52	0.46	0.47	0.42	0.5	0.49
Total Phosphorus (mg/L)	0.83			0.76	1		0.95	
Bromodichloromethane (ug/L)	1300	1900	1800	2100	2100	2600	2400	2500
Bromoform (ug/L)	<833	<833	<833	<833	<833	<833	<833	<833
Chloroform (ug/L)	16000	15000	14000	16000	15000	16000	18000	16000
Dibromochloromethane (ug/L)	<833	<833	<833	<833	<833	<833	<833	<833
TOTAL THMFP (ug/L)	17300	16900	15800	18100	17100	18600	20400	18500
Field Measurements:								
Temperature	26.2	21.4	22.4	27.1	25.6	23.3	26.4	20.6
EC	1017	1044	1094	1434	2000	1516	1762	1730
DO								
pH	5.7	5.81	5.9	5.59	5.85	5.89	5.72	6.04

NOTES:

Modified sampling schedule has peat tanks sampled once per month, 4 tanks sampled on alternate weeks, due to high turbidity and cost of filtering.

Data for Tanks 6 and 8 are accurate.

Added 61 gallons fresh water to Tank 7 on 8/12/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Peat Water

3rd MONTH

Sample dates: September 9* and September 17, 1998**

PARAMETER	TANK 1*	TANK 2**	TANK 3**	TANK 4*	TANK 5*	TANK 6**	TANK 7*	TANK 8**
TOC (mg/L)	64.5	317	307	336		369	409	404
DOC (mg/L)	57.6	301	283	324		339	386	374
UVA (mg/L)	3.5	16.3	15	16.5		16.9	19.9	19.2
Specific Absorbance Calc.	6.08	5.42	5.30	5.09		4.99	5.16	5.13
Alkalinity (mg/L)	100	366	380	409		407	507	527
Ammonia (mg/L)	2	13	12	12		13	15	15
Bromide (mg/L)								
Nitrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)	5.8	29	26	26		28	32	33
Dis. Orthophosphate (mg/L)								
Total Phosphorus (mg/L)	0.39	1	0.86	0.86		0.77	1.3	1.2
Bromodichloromethane (ug/L)	460	2800	3000	3400		3800	3300	4000
Bromoform (ug/L)	<125	<833	<833	<833		<833	<833	<833
Chloroform (ug/L)	4300	18000	16000	17000		19000	20000	20000
Dibromochloromethane (ug/L)	<125	<833	<833	<833		<833	<833	<833
TOTAL THMFP (ug/L)	4760	20800	19000	20400	0	22800	23300	24000
Field Measurements:								
Temperature	20.2	22.5	20.8	22.1		20.1	23.6	21.2
EC	345	1138	1181	1388		1535	1637	1765
DO								
pH	5.88	5.98	6	5.64		6.47	5.81	6.08

NOTES:

Modified sampling schedule has peat tanks sampled once per month, 4 tanks sampled on alternate weeks, due to high turbidity and cost of filtering.

Data for Tanks 6 and 8 are accurate.

Tank 5 not sampled; could not get any water from the spigot.

Added 61 gallons of fresh water to Tank 7 on 8/19/98. Added 49.5 gallons fresh water to Tank 1 and 23.1 gallons to Tank 7 on 9/2/98.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 1 - July 15, 1998 through October 7, 1998

Peat Water

4th MONTH

Sample date: October 7, 1998

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	75.7	285	276	308	331	346	351	373
DOC (mg/L)	74.1	279	270	301	323	341	341	358
UVA (mg/L)	4.34	16.6	15.7	17.8	18.2	18.1	20.4	20.8
Specific Absorbance Calc.	5.86	5.95	5.81	5.91	5.63	5.31	5.98	5.81
Alkalinity (mg/L)	122	384	408	439	577	450	541	565
Ammonia (mg/L)	2.6	14	13	14	16	14	16	16
Bromide (mg/L)	0.89	4.38	5.14	5.54	7.06	6.72	5.56	6.76
Nitrate + Nitrite (mg/L)	0.2	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen (mg/L)	7.3	32	30	33	35	30	18	30
Dis. Orthophosphate (mg/L)	0.13	0.5	0.48	0.49	0.59	0.54	0.54	0.58
Total Phosphorus (mg/L)	0.44	0.92	0.95	0.95	1.1	0.75	0.71	0.7
Bromodichloromethane (ug/L)	400	2200	2600	2700	3400	41000	2800	3100
Bromoform (ug/L)	<167	<833	<833	<833	<833	<833	<833	<833
Chloroform (ug/L)	3600	13000	12000	14000	13000	18000	15000	14000
Dibromochloromethane (ug/L)	<167	<833	<833	<833	<833	860	<833	<833
TOTAL THMFP (ug/L)	4000	15200	14600	16700	16400	59860	17800	17100
Field Measurements:								
Temperature	16.8	17.8	17.3	16.7	21.2	18.9	17.9	18.8
EC	395	1141	1226	1446	1852	1830	1590	1563
pH	6.25	5.96	6.02	6.03	6.31	6.25	6.02	6.14

NOTES:

Modified sampling schedule has peat tanks sampled once per month, 4 tanks sampled on alternate weeks, due to high turbidity and cost of filtering.

Data for Tanks 6 and 8 are accurate.

Added 60 gallons fresh water to Tank 3 and 54 gallons to Tank 7 on 9/23/98.

Results of Algae Identification and Biomass Sample from SMARTS tanks 7/28/98					
Sample Date	**Sample Number**	**Genus**	**Species**	**Genus Biomass (mg/L)**	**Sample Biomass (mg/L)**
7/28/98	Tank1	Gonium	pect?	0.04	
7/28/98	Tank1	Gymnodinium		0.02	
7/28/98	Tank1	Pandorina	morum	0.08	
7/28/98	Tank1	Trachelomonas		0.08	
7/28/98	Tank1	Ulothrix	subtilissima	0.35	
7/28/98	Tank1	Synedra	ulna	0.94	
7/28/98	Tank1	Unidentified	Flagellates	0.38	
7/28/98	Tank1				1.88
7/28/98	Tank2	Mallomonas	psue?	0.02	
7/28/98	Tank2	Scenedesmus	quadricauda	0.15	
7/28/98	Tank2	Melosira	granulata	0.22	
7/28/98	Tank2	Ankistrodesmus	falcatus	0.17	
7/28/98	Tank2	Skeletonema	potamos	0.01	
7/28/98	Tank2	Unidentified	Flagellates	0.01	0.58
7/28/98	Tank2				
7/28/98	Tank3	Oedogonium		0.12	
7/28/98	Tank3	Synedra	ulna	0.09	
7/28/98	Tank3	Chlamydomonas		1.88	2.09
7/28/98	Tank3				
7/28/98	Tank4	Oedogonium		0.12	
7/28/98	Tank4	Synedra		0.04	
7/28/98	Tank4	Ulothrix	subtilissima	1.32	
7/28/98	Tank4	Achnanthes	lanceolata	0.05	
7/28/98	Tank4	Microspora		2.09	
7/28/98	Tank4	Euglena		0.04	
7/28/98	Tank4	Oocystis		0.18	
7/28/98	Tank4	Cyclotella		0.02	
7/28/98	Tank4				3.86
7/28/98	Tank5	Anabaena		0.12	
7/28/98	Tank5	Synedra	ulna	0.03	
7/28/98	Tank5	Chlamydomonas		0.05	
7/28/98	Tank5	Cryptomonas	ovata	0.000	
7/28/98	Tank5				0.19
7/28/98	Tank6	Eudorina	elegans	0.29	
7/28/98	Tank6	Ulothrix	subtilissima	0.05	
7/28/98	Tank6	Cryptomonas	ovata	0.01	
7/28/98	Tank6	Sphaerocystis	schroeteri	0.24	
7/28/98	Tank6				0.59
7/28/98	Tank7	None		0.00	

7/28/98	Tank8	Gonium	?	0.182	
7/28/98	Tank8	Pandorina	morum	0.495	
7/28/98	Tank8	Chlorella		0.287	
7/28/98	Tank8	Cryptomonas	ovata	0.027	
7/28/98	Tank8	Cyclotella		0.01	
7/28/98	Tank8	Dictyosphae	pulchellum	0.20	
7/28/98	Tank8				1.20
7/28/98	Tank9	Anabaena		0.02	
7/28/98	Tank9	Chlorella		0.00	
7/28/98	Tank9	Cyclotella		0.00	
7/28/98	Tank9	Unidentified	Flagellates	0.01	
7/28/98	Tank9				0.04
7/28/98	Tank10 (Tank 5 duplicate)	Oscillatoria		0.05	
7/28/98	Tank10	Pandorina	morum	0.10	
7/28/98	Tank10	Chlorella		0.02	
7/28/98	Tank10	Ulothrix	subtilissima	0.08	
7/28/98	Tank10	Synedra	ulna	0.01	
7/28/98	Tank10	Chlamydomonas		0.05	
7/28/98	Tank10	Cryptomonas	ovata	0.03	
7/28/98	Tank10	Cyclotella		0.02	
7/28/98	Tank10	Unidentified	Flagellates	0.01	
7/28/98	Tank10				0.35
7/28/98	Tank11 (surface skim of tank 4)	Microspora			
7/28/98		Navicula			
7/28/98		Pandorina	morum		
7/28/98		Chlorella			
7/28/98		Ulothrix	subtilissima		
7/28/98		Achnanthes	lanceolata		
7/28/98		Melosira	granulata		
7/28/98		Synedra	ulna		
7/28/98		Selenastrum			
7/28/98		Palmellococcus			
7/28/98		Chlamydomonas			
7/28/98		Sphaerocystis	schroeteri		
7/28/98		Oedogonium			

Appendix C

Effects Table and Charts

Data Summary and Effects Table for Two-Cubed Factorial Experiment

SUMMARY OF EXPERIMENTAL DATA AND EFFECTS

Response variable name: TOC Experiment #1 at 10 weeks

Enter Response Variable in dependent variable column for each SMARTS tank designated in last column.
Factors 1, 2, and 3 in order are: peat soil depth, water depth, and water exchange rate.
Interaction effects are designated as columns 12,13, and 123.
Italicized numbers 0 and 1 designate - and + treatments (low and high) in each tank.

Runs/Factor		1	2	3	12	13	23	123	Dep.Var.	SMARTS Tank #
	1	*0*	*0*	*0*	*1*	*1*	*1*	*0*	38	**1**
	2	*1*	*0*	*0*	*0*	*0*	*1*	*1*	166	**3**
	3	*0*	*1*	*0*	*0*	*1*	*0*	*1*	17.7	**7**
	4	*1*	*1*	*0*	*1*	*0*	*0*	*0*	33.3	**5**
	5	*0*	*0*	*1*	*1*	*0*	*0*	*1*	6.2	**2f**
	6	*1*	*0*	*1*	*0*	*1*	*0*	*0*	8.3	**4f**
	7	*0*	*1*	*1*	*0*	*0*	*1*	*0*	3	**6f**
	8	*1*	*1*	*1*	*1*	*1*	*1*	*1*	2.3	**8f**
Sum (1)		209.9	56.3	19.8	79.8	66.3	209.3	192.2		
Sum (0)		64.9	218.5	255	195	208.5	65.5	82.6		
Avg (1)		52.48	14.08	4.95	19.95	16.58	52.33	48.05		
Avg (0)		16.23	54.63	63.75	48.75	52.13	16.38	20.65		
Effect		***36.25***	***-40.55***	***-58.8***	***-28.8***	***-35.55***	***35.95***	***27.4***		
Normal order score		1.352	-0.757	-1.352	0	-0.353	0.757	0.353		
Rank order		7	2	1	4	3	6	5		
P value		0.93	0.21	0.07	0.50	0.36	0.79	0.64		

Main Effects Data for Graphs

	Treatment	Chart 1 Factor 1	Treatment	Chart 2 Factor 2	Treatment	Chart 3 Factor 3
Avg (0)	Low	16.23	Low	54.63	Low	63.75
Avg(1)	High	52.48	High	14.08	High	4.95

Interaction Effects Data for Graphs

	Chart 4 Factors 1 and 2 Interaction F1F2			Chart 5 Factors 1 and 3 Interaction F1F3			Chart 6 Factors 2 and 3 Interaction F2F3		
		F2 Low	F2 High		F3 Low	F3 High		F3 Low	F3 High
Avg (0)	F1 Low	22.10	10.35	F1 Low	27.85	4.60	F2 Low	102.00	7.25
Avg(1)	F1 High	87.15	17.80	F1 High	99.65	5.30	F3 High	25.50	2.65

Note: If lines on chart intersect there is interaction.

Lookup table:

Chart 7 is a normal plot of effects

Rank order	Normal order score
1	-1.352
2	-0.757
3	-0.353
4	0
5	0.353
6	0.757
7	1.352

Chart 1. Factor 1 (Peat) Main Effects

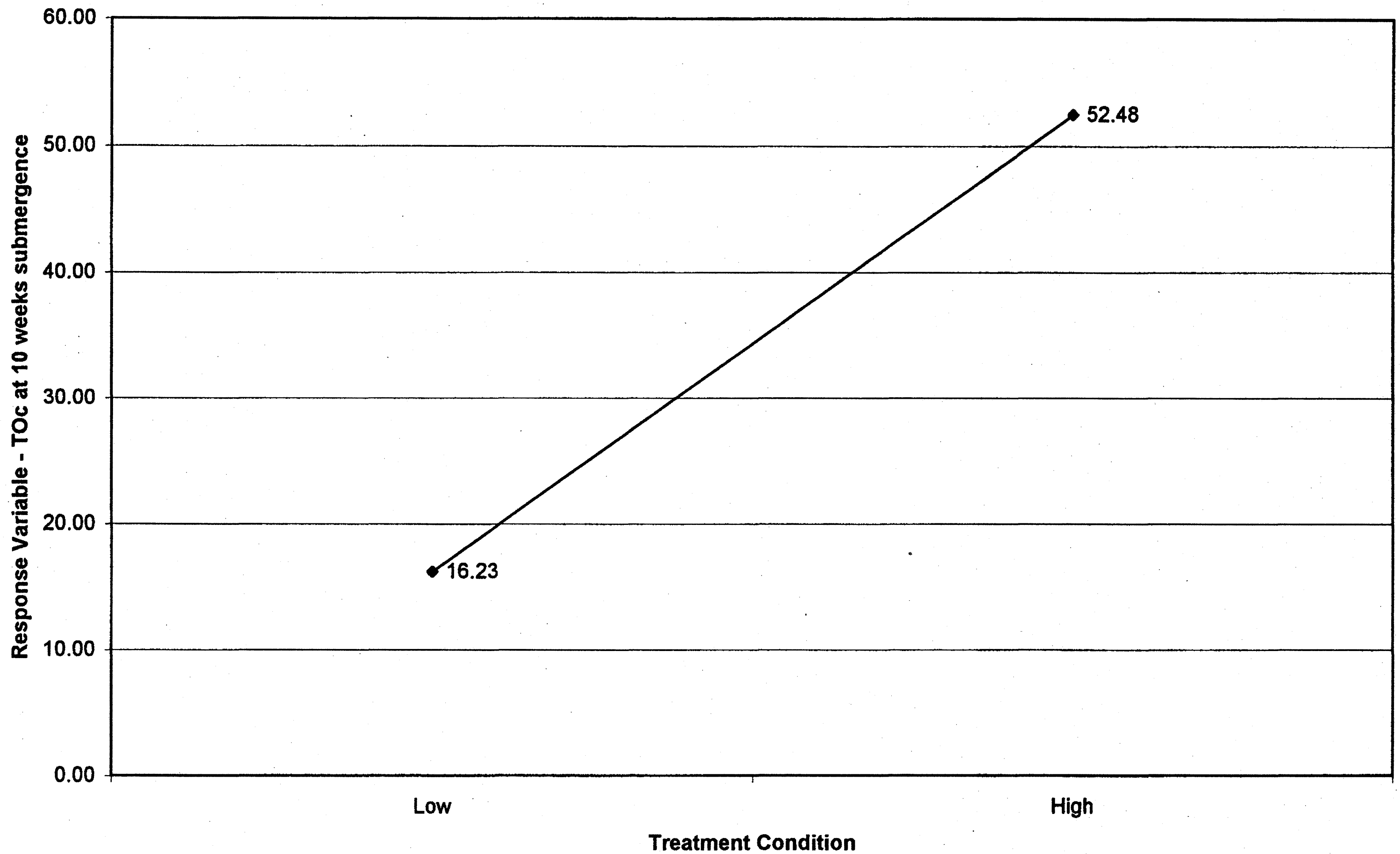


Chart 2. Factor 2 (Water Depth) Main Effects

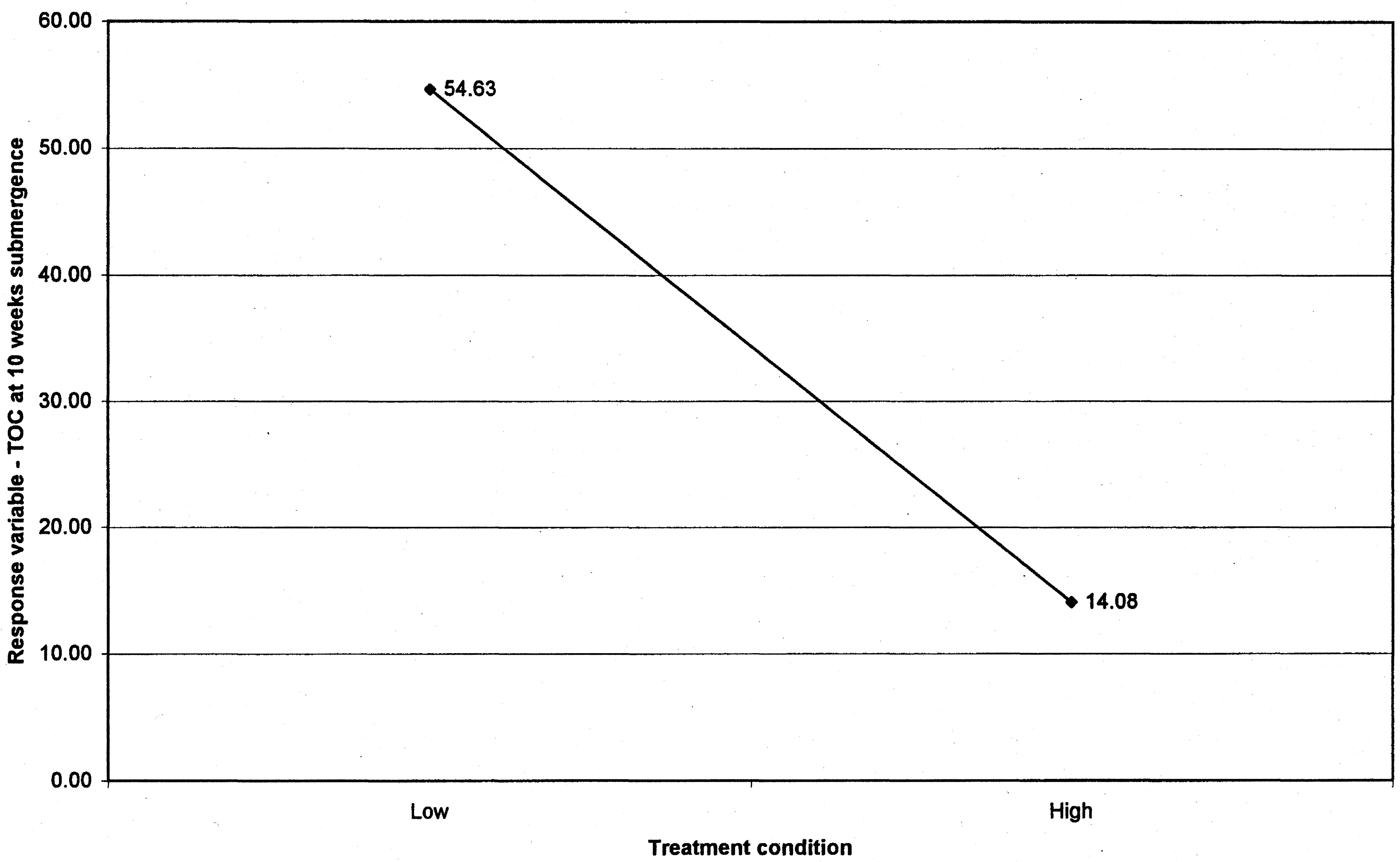


Chart 3. Factor 3 (Water Exchange) Main Effects

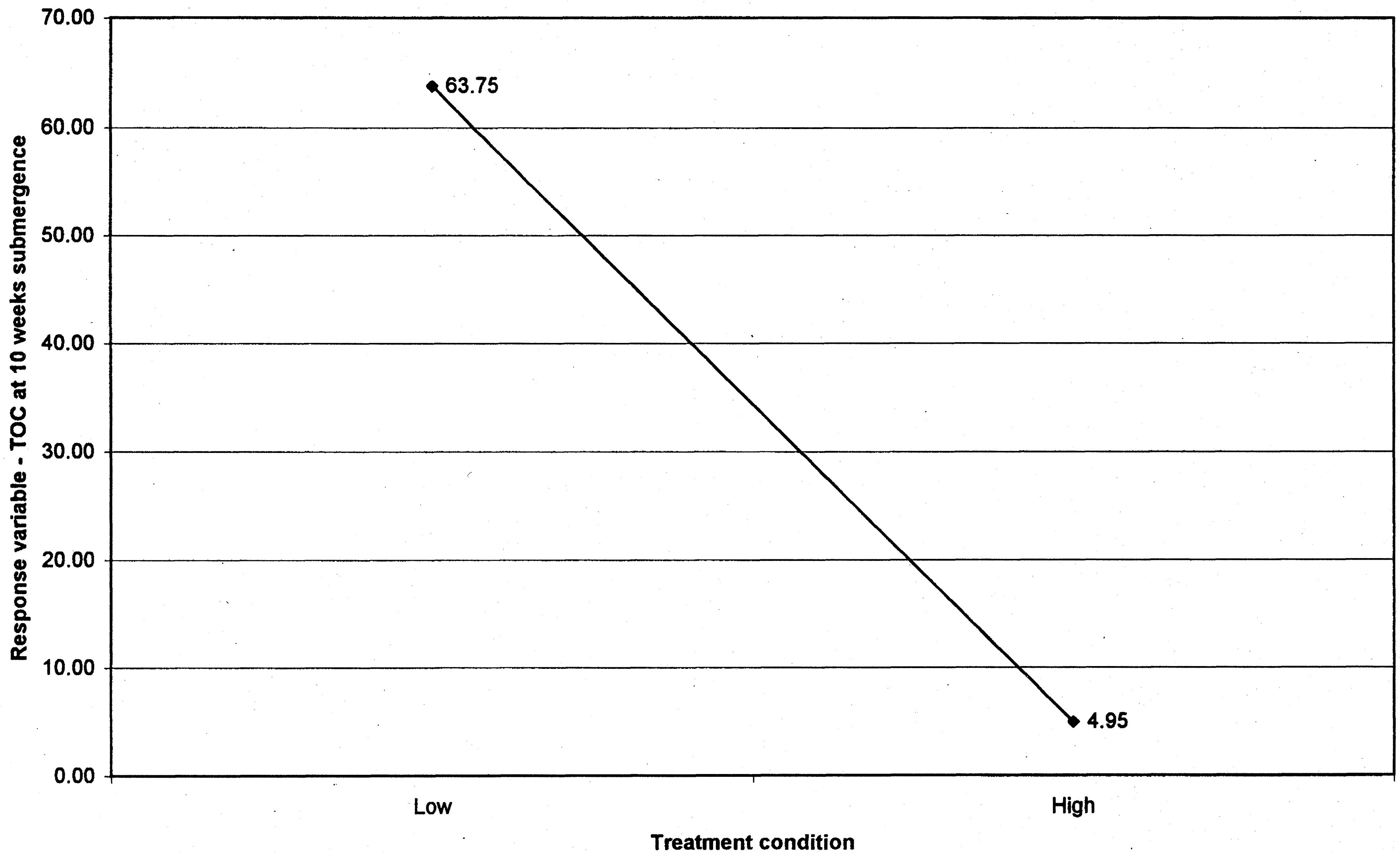


Chart 4. F1 (Peat) F2 (Water Depth) Interaction

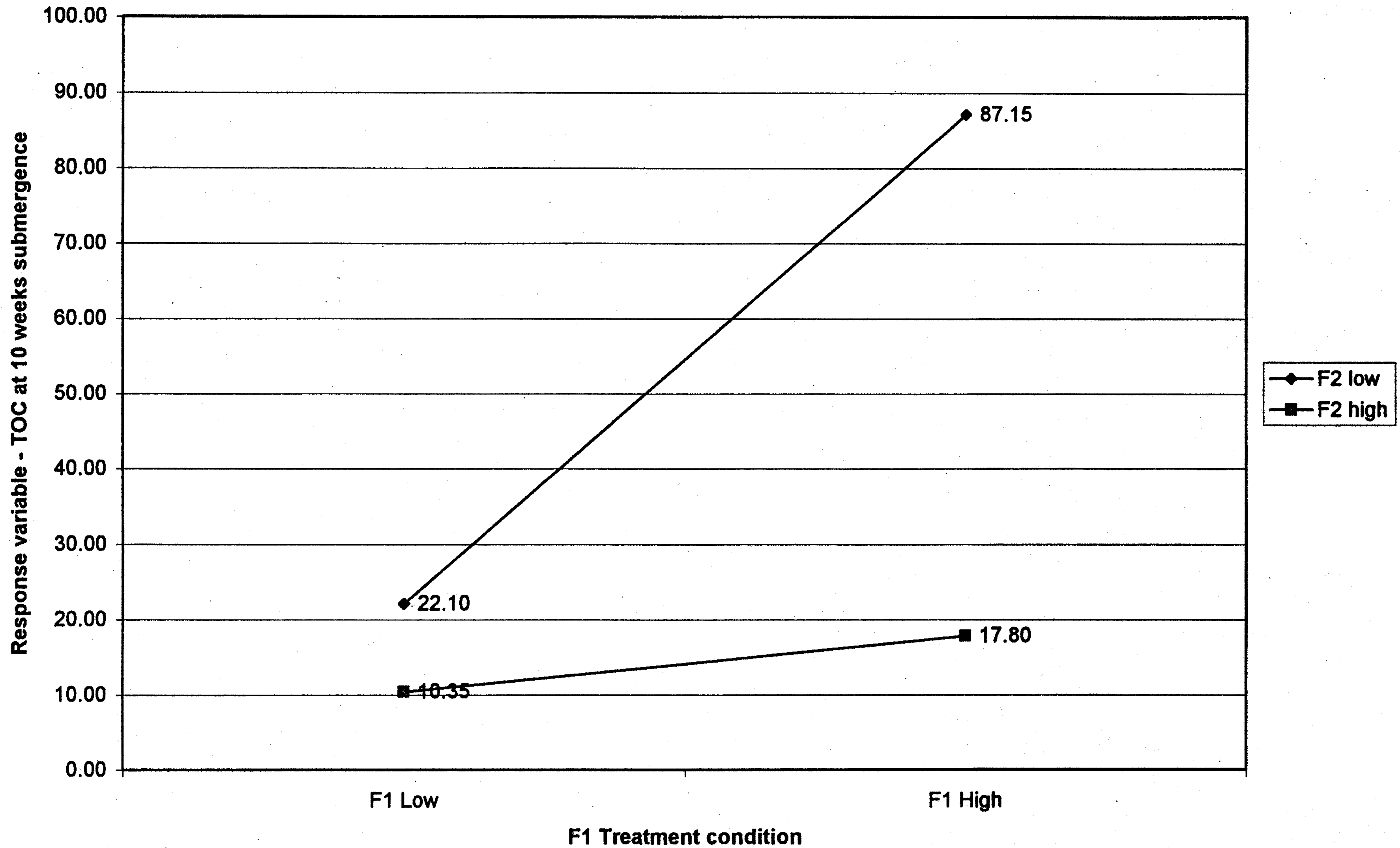


Chart 5. F1 (Peat) F3 (Water Exchange) Interaction

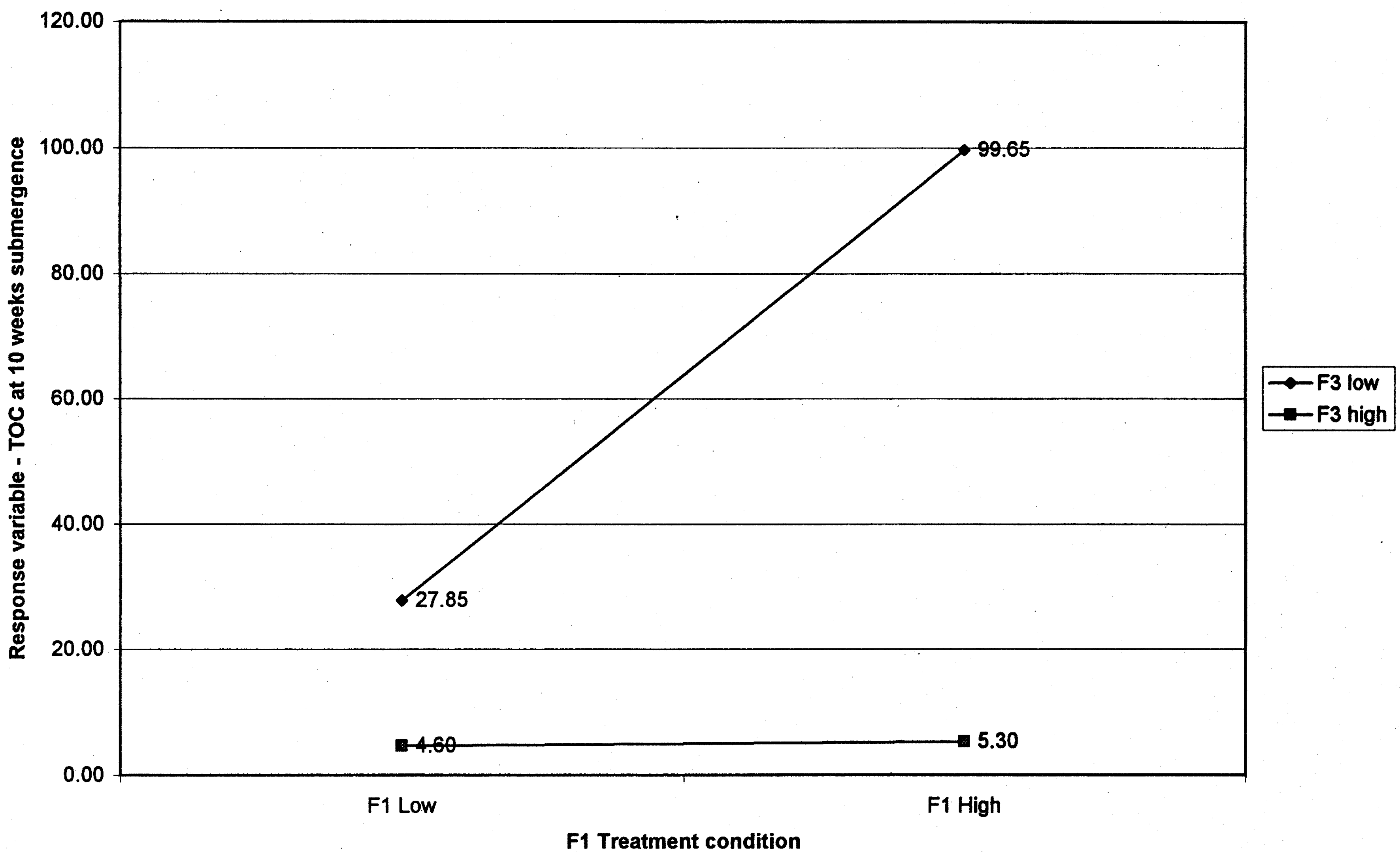


Chart 6. F2 (Water Depth) F3 (Water Exchange) Interaction

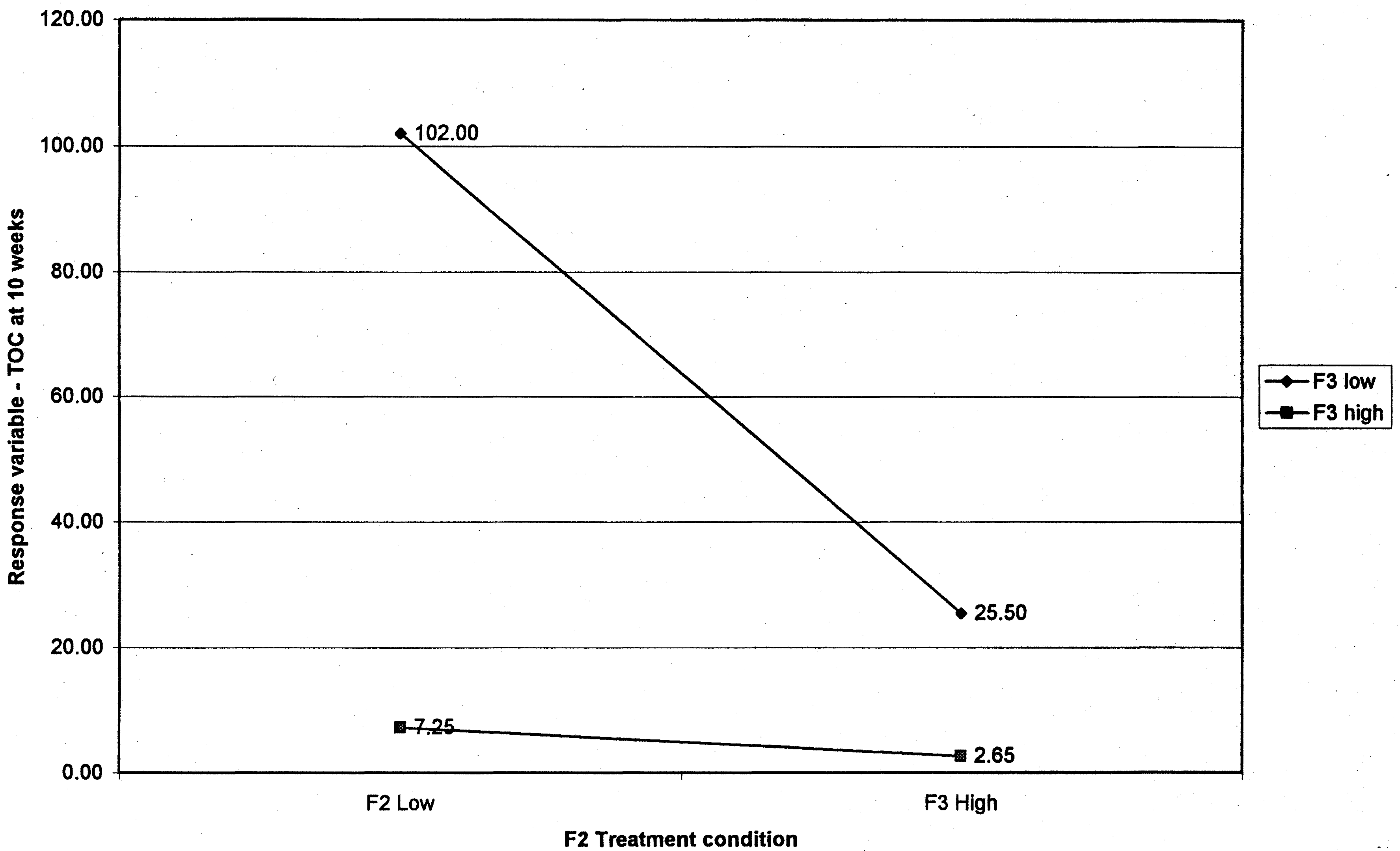
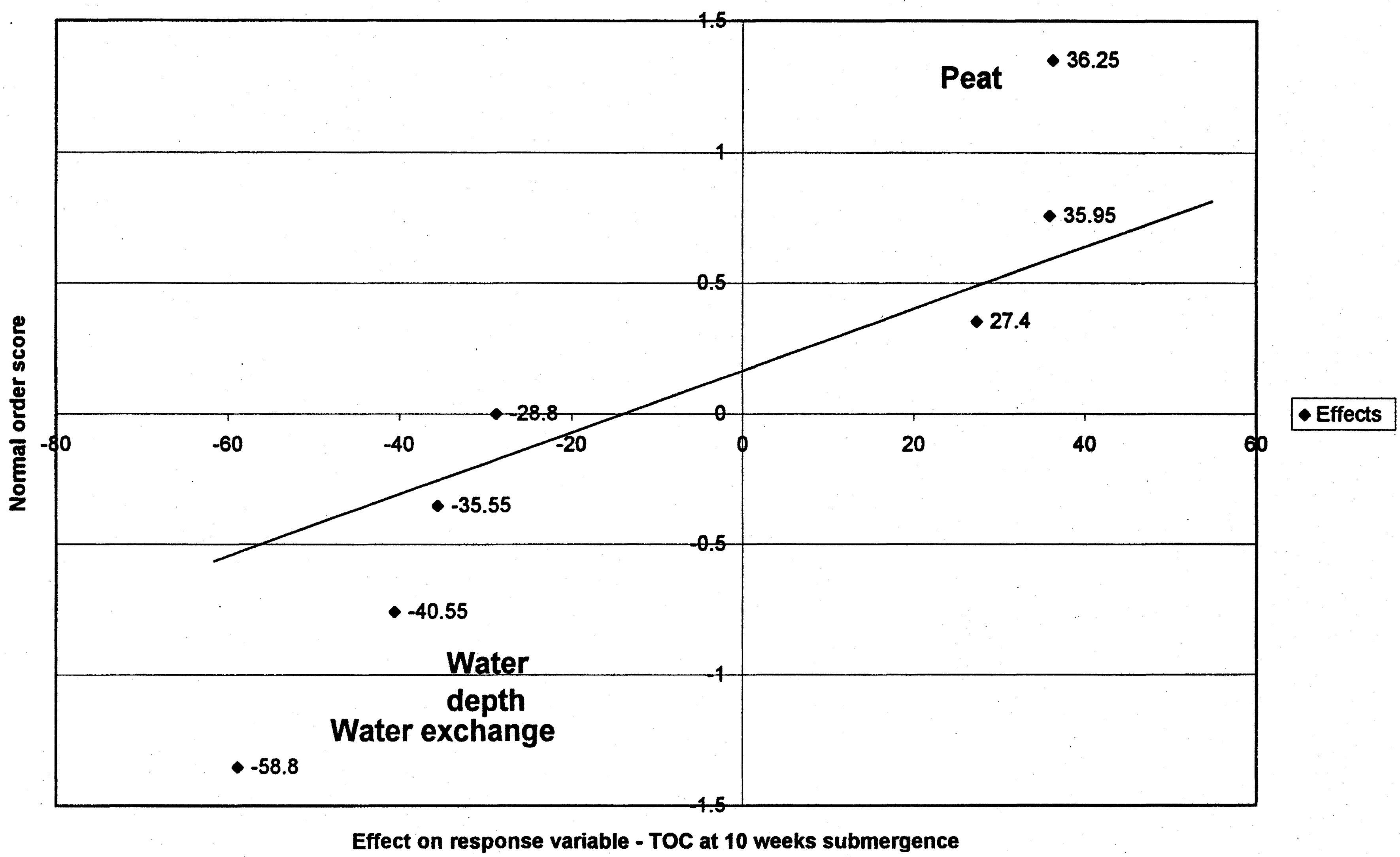


Chart 7. Main Effect Normal Probability Plot



Data Summary and Effects Table for Two-Cubed Factorial Experiment

SUMMARY OF EXPERIMENTAL DATA AND EFFECTS

Response variable name: DOC - Experiment#1 at 10 weeks submergence

Enter Response Variable in dependent variable column for each SMARTS tank designated in last column.
Factors 1, 2, and 3 in order are: peat soil depth, water depth, and water exchange rate.
Interaction effects are designated as columns 12,13, and 123.
Italicized numbers 0 and 1 designate - and + treatments (low and high) in each tank.

Runs/Factor		**1**	**2**	**3**	**12**	**13**	**23**	**123**	**Dep.Var.**	**SMARTS Tank #**
	1	*0*	*0*	*0*	*1*	*1*	*1*	*0*	***39.4***	**1**
	2	*1*	*0*	*0*	*0*	*0*	*1*	*1*	***108***	**3**
	3	*0*	*1*	*0*	*0*	*1*	*0*	*1*	***16.5***	**7**
	4	*1*	*1*	*0*	*1*	*0*	*0*	*0*	***26***	**5**
	5	*0*	*0*	*1*	*1*	*0*	*0*	*1*	***5.2***	**2f**
	6	*1*	*0*	*1*	*0*	*1*	*0*	*0*	***8.3***	**4f**
	7	*0*	*1*	*1*	*0*	*0*	*1*	*0*	***2.8***	**6f**
	8	*1*	*1*	*1*	*1*	*1*	*1*	*1*	***1.9***	**8f**
Sum (1)		144.2	47.2	18.2	72.5	66.1	152.1	131.6		
Sum (0)		63.9	160.9	189.9	135.6	142	56	76.5		
Avg (1)		36.05	11.80	4.55	18.13	16.53	38.03	32.90		
Avg (0)		15.98	40.23	47.48	33.90	35.50	14.00	19.13		
Effect		***20.075***	***-28.425***	***-42.925***	***-15.775***	***-18.975***	***24.025***	***13.775***		
Normal order score		0.757	-0.757	-1.352	0	-0.353	1.352	0.353		
Rank order		6	2	1	4	3	7	5		
P value		0.79	0.21	0.07	0.50	0.36	0.93	0.64		

Main Effects Data for Graphs

		Chart 1		**Chart 2**		**Chart 3**
	Treatment	**Factor 1**	**Treatment**	**Factor 2**	**Treatment**	**Factor 3**
Avg (0)	Low	15.98	Low	40.23	Low	47.48
Avg(1)	High	36.05	High	11.80	High	4.55

Interaction Effects Data for Graphs

	Chart 4 Factors 1 and 2			**Chart 5 Factors 1 and 3**			**Chart 6 Factors 2 and 3**		
	Interaction F1F2			**Interaction F1F3**			**Interaction F2F3**		
		F2 Low	F2 High		F3 Low	F3 High		F3 Low	F3 High
Avg (0)	F1 Low	22.30	9.65	F1 Low	27.95	4.00	F2 Low	73.70	6.75
Avg(1)	F1 High	58.15	13.95	F1 High	67.00	5.10	F3 High	21.25	2.35

Note: If lines on chart intersect there is interaction.

Lookup table:

Rank order	**Normal order score**
1	-1.352
2	-0.757
3	-0.353
4	0
5	0.353
6	0.757
7	1.352

Chart 7 in normal plot of effects

Chart 1. Factor 1 (Peat) Main Effects

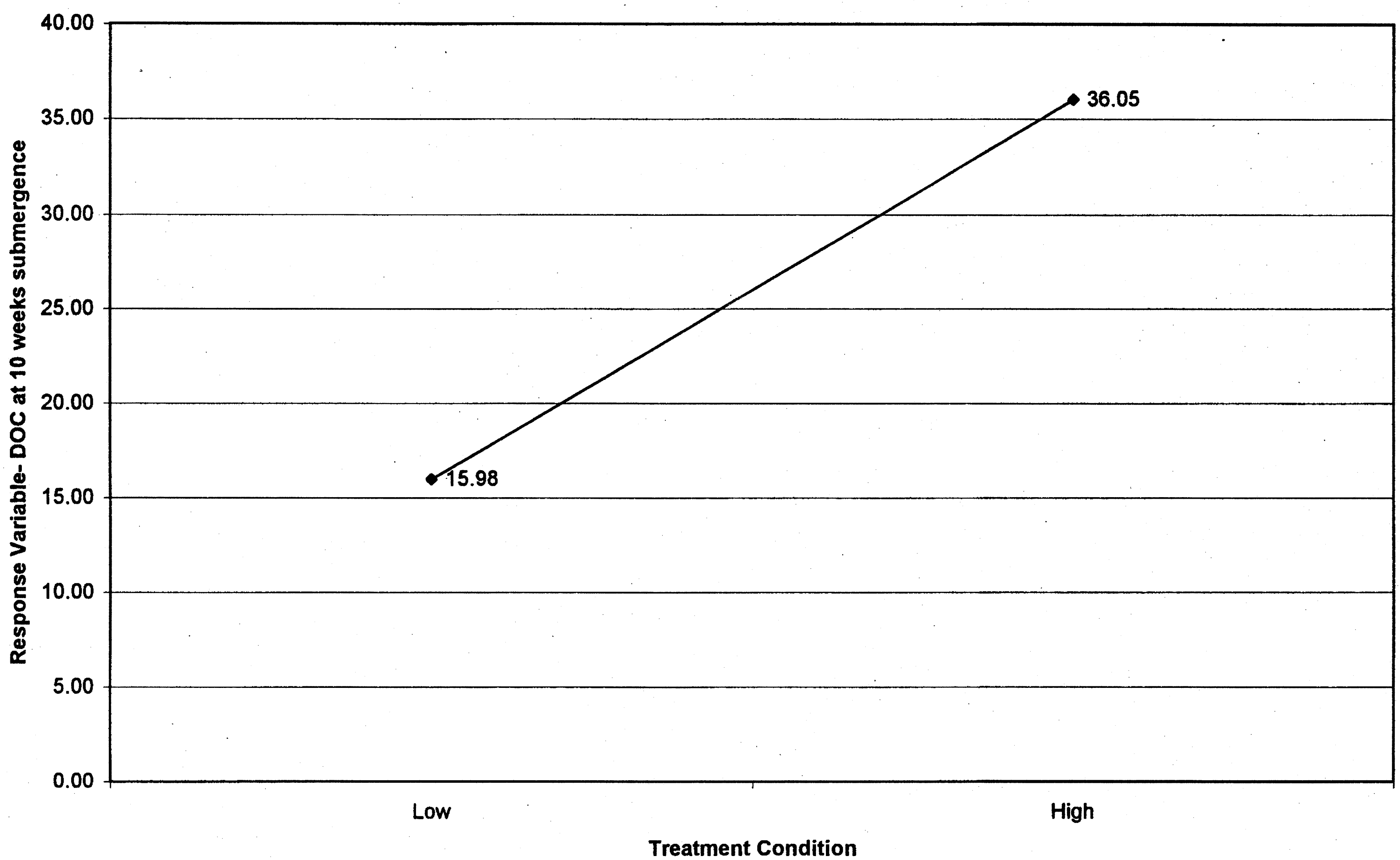


Chart 2. Factor 2 (Water Depth) Main Effects

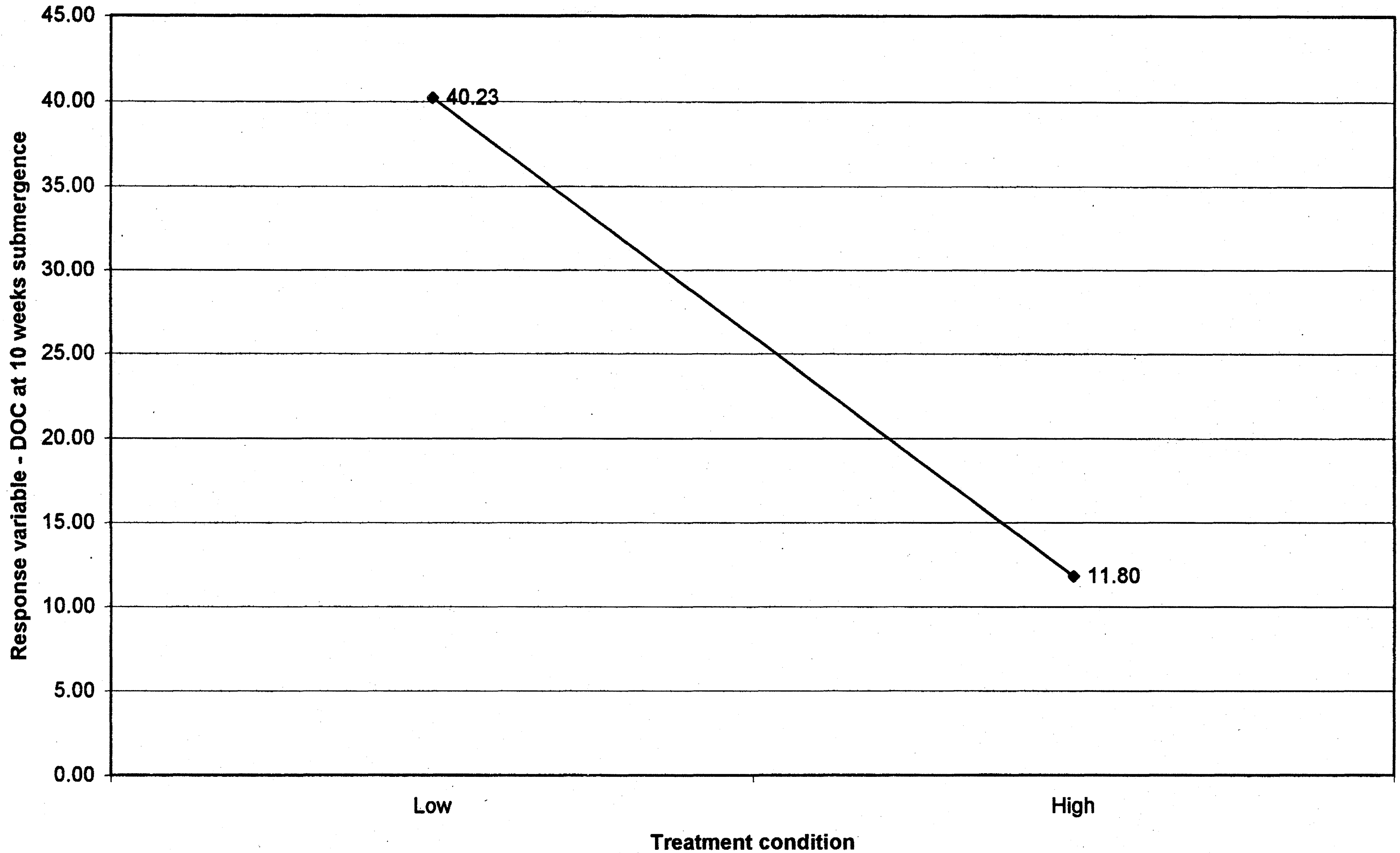


Chart 3. Factor 3 (Water Exchange) Main Effects

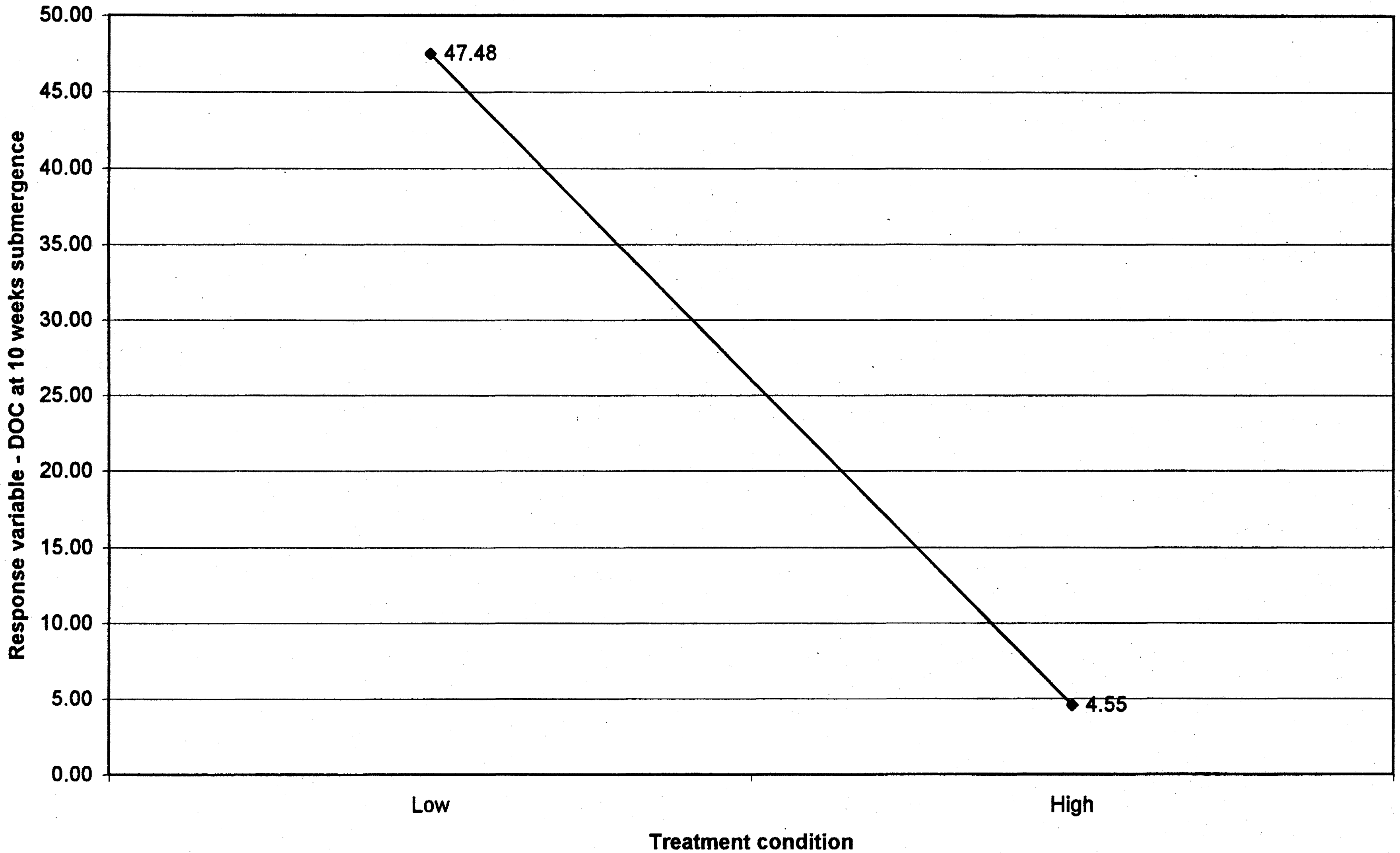


Chart 4. F1 (Peat) F2 (Water Depth) Interaction

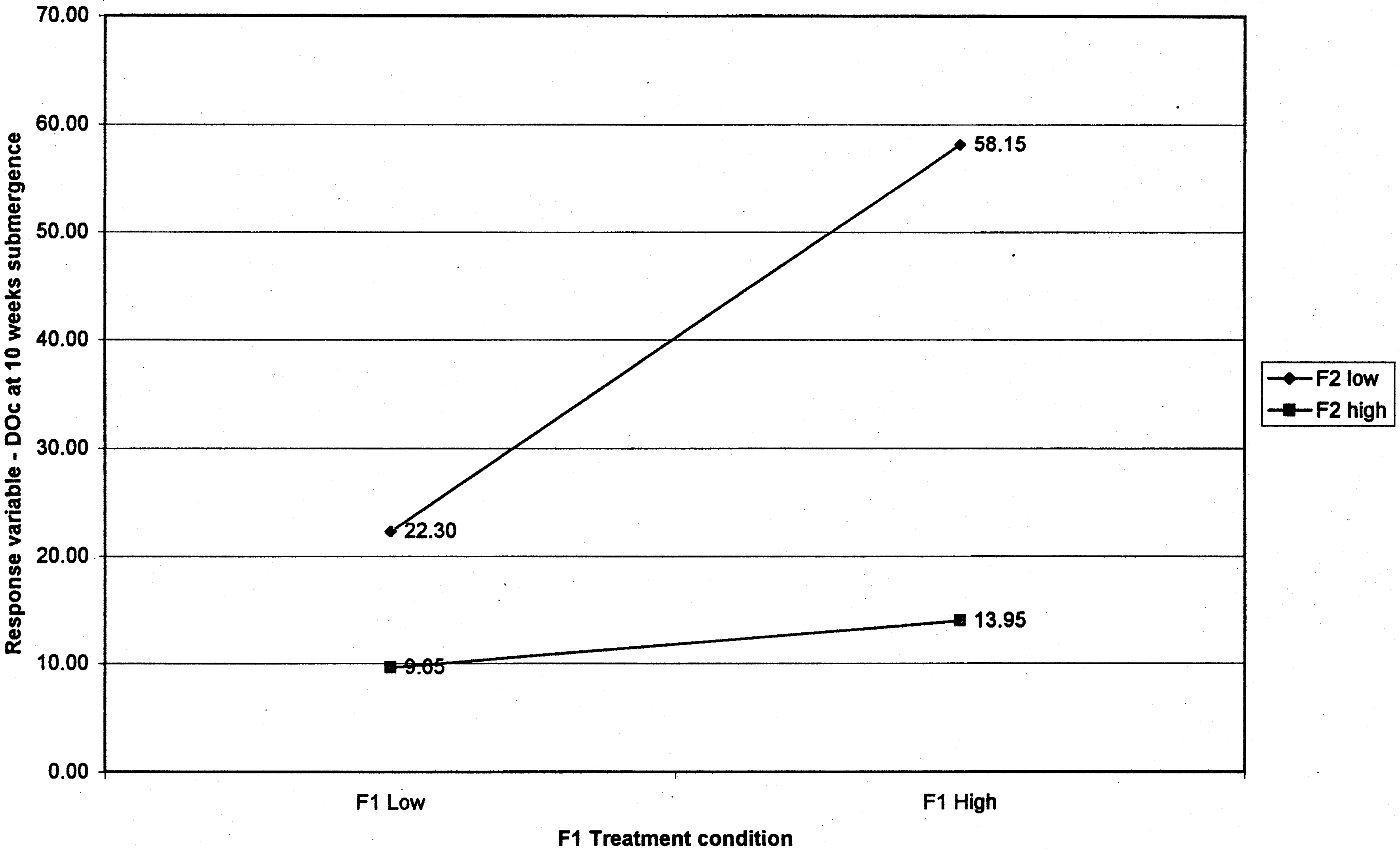


Chart 5. F1 (Peat) F3 (Water Exchange) Interaction

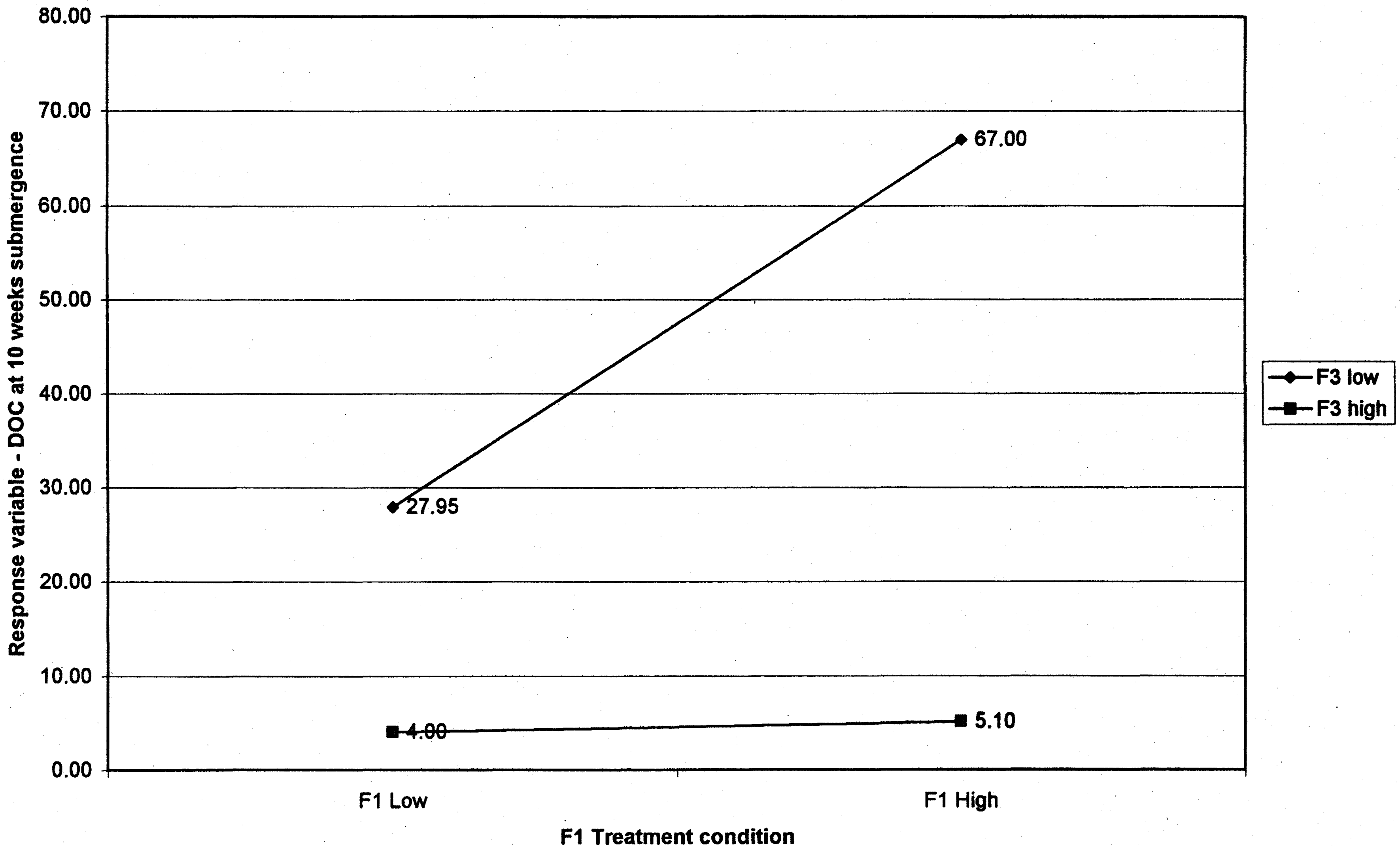
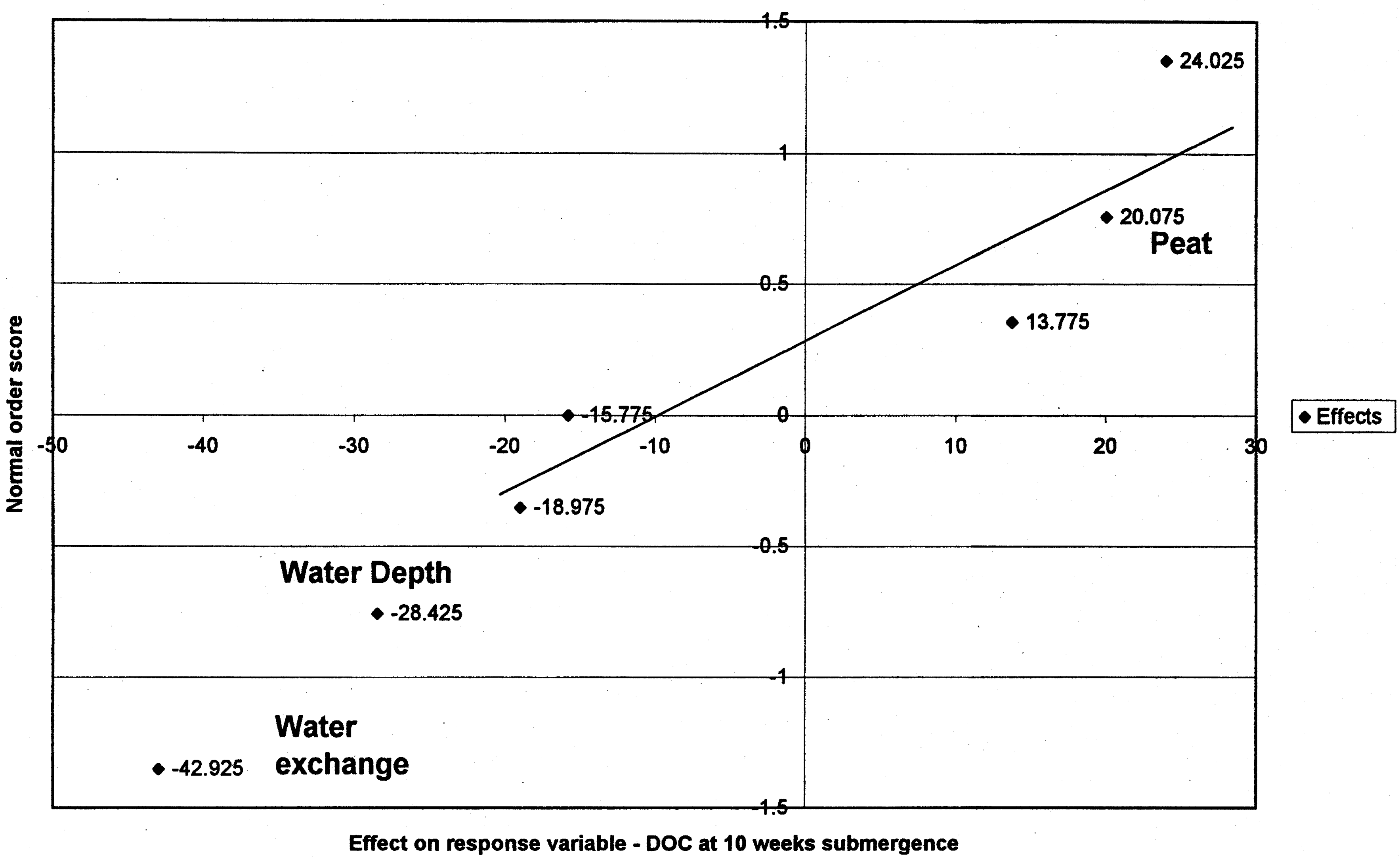


Chart 7. Main Effect Normal Probability Plot



Data Summary and Effects Table for Two-Cubed Factorial Experiment

SUMMARY OF EXPERIMENTAL DATA AND EFFECTS

Response variable name: TTHMFP Experiment #1 at 10 weeks submergence

Enter Response Variable in dependent variable column for each SMARTS tank designated in last column.
Factors 1, 2, and 3 in order are: peat soil depth, water depth, and water exchange rate.
Interaction effects are designated as columns 12,13, and 123.
Italicized numbers 0 and 1 designate - and + treatments (low and high) in each tank.

Runs/Factor		**1**	**2**	**3**	**12**	**13**	**23**	**123**	**Dep.Var.**	**SMARTS Tank #**
	1	*0*	*0*	*0*	*1*	*1*	*1*	*0*	***3310***	**1**
	2	*1*	*0*	*0*	*0*	*0*	*1*	*1*	***11300***	**3**
	3	*0*	*1*	*0*	*0*	*1*	*0*	*1*	***1430***	**7**
	4	*1*	*1*	*0*	*1*	*0*	*0*	*0*	***2190***	**5**
	5	*0*	*0*	*1*	*1*	*0*	*0*	*1*	***508***	**2f**
	6	*1*	*0*	*1*	*0*	*1*	*0*	*0*	***714***	**4f**
	7	*0*	*1*	*1*	*0*	*0*	*1*	*0*	***242***	**6f**
	8	*1*	*1*	*1*	*1*	*1*	*1*	*1*	***158***	**8f**
Sum (1)		14362	4020	1622	6166	5612	15010	13396		
Sum (0)		5490	15832	18230	13686	14240	4842	6456		
Avg (1)		3590.50	1005.00	405.50	1541.50	1403.00	3752.50	3349.00		
Avg (0)		1372.50	3958.00	4557.50	3421.50	3560.00	1210.50	1614.00		
Effect		***2218***	***-2953***	***-4152***	***-1880***	***-2157***	***2542***	***1735***		
Normal order score		0.757	-0.757	-1.352	0	-0.353	1.352	0.353		
Rank order		6	2	1	4	3	7	5		
P value		0.79	0.21	0.07	0.50	0.36	0.93	0.64		

Main Effects Data for Graphs

	Treatment	**Chart 1 Factor 1**	**Treatment**	**Chart 2 Factor 2**	**Treatment**	**Chart 3 Factor 3**
Avg (0)	Low	1372.50	Low	3958.00	Low	4557.50
Avg(1)	High	3590.50	High	1005.00	High	405.50

Interaction Effects Data for Graphs

	Chart 4 Factors 1 and 2 Interaction F1F2			**Chart 5 Factors 1 and 3 Interaction F1F3**			**Chart 6 Factors 2 and 3 Interaction F2F3**		
		F2 Low	F2 High		F3 Low	F3 High		F3 Low	F3 High
Avg (0)	F1 Low	1909.00	836.00	F1 Low	2370.00	375.00	F2 Low	7305.00	611.00
Avg(1)	F1 High	6007.00	1174.00	F1 High	6745.00	436.00	F3 High	1810.00	200.00

Note: If lines on chart intersect there is interaction.

Lookup table:

Rank order	**Normal order score**
1	-1.352
2	-0.757
3	-0.353
4	0
5	0.353
6	0.757
7	1.352

Chart 7 is normal plot of effects

Chart 1. Factor 1 (Peat) Main Effects

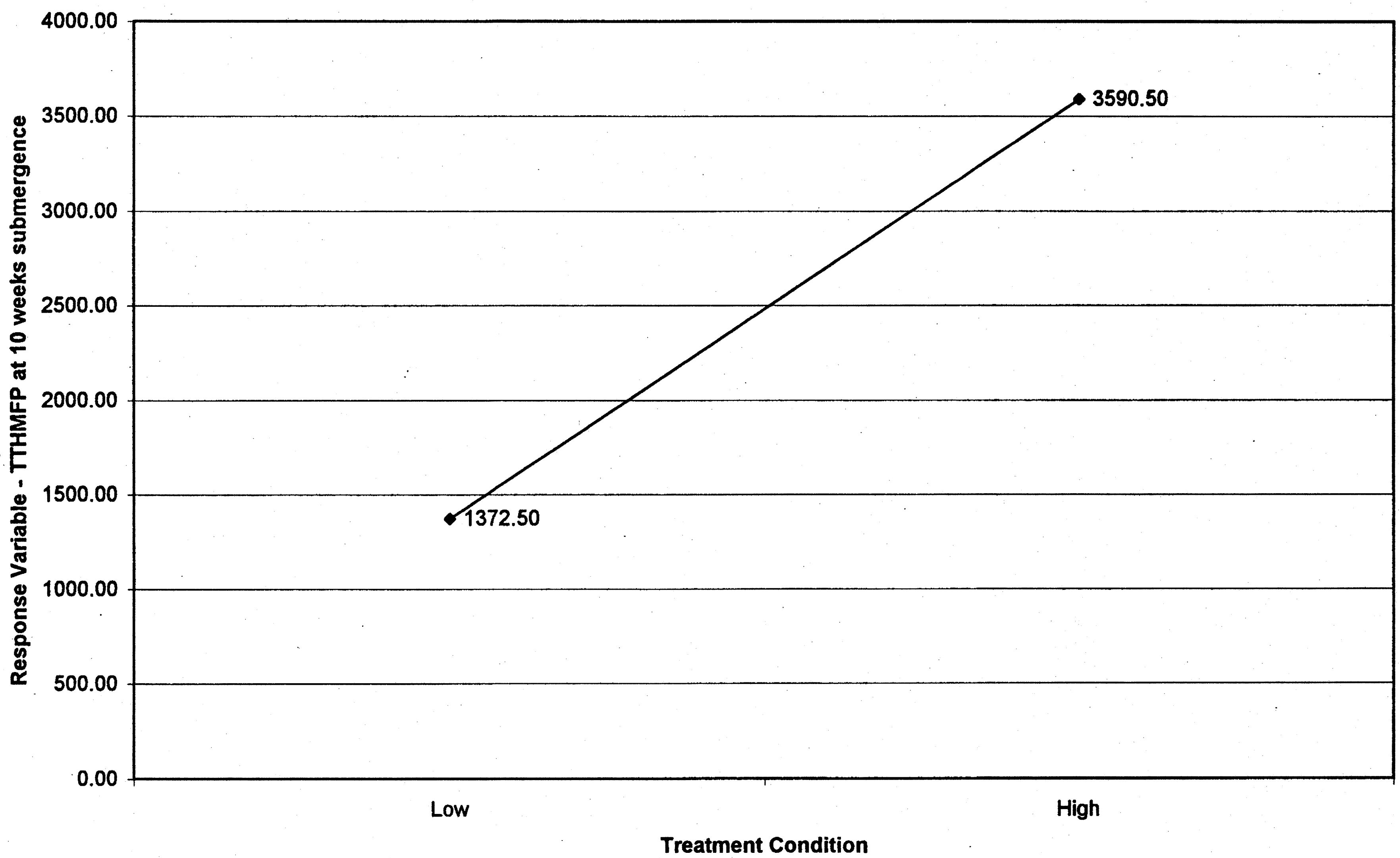


Chart 2. Factor 2 (Water Depth) Main Effects

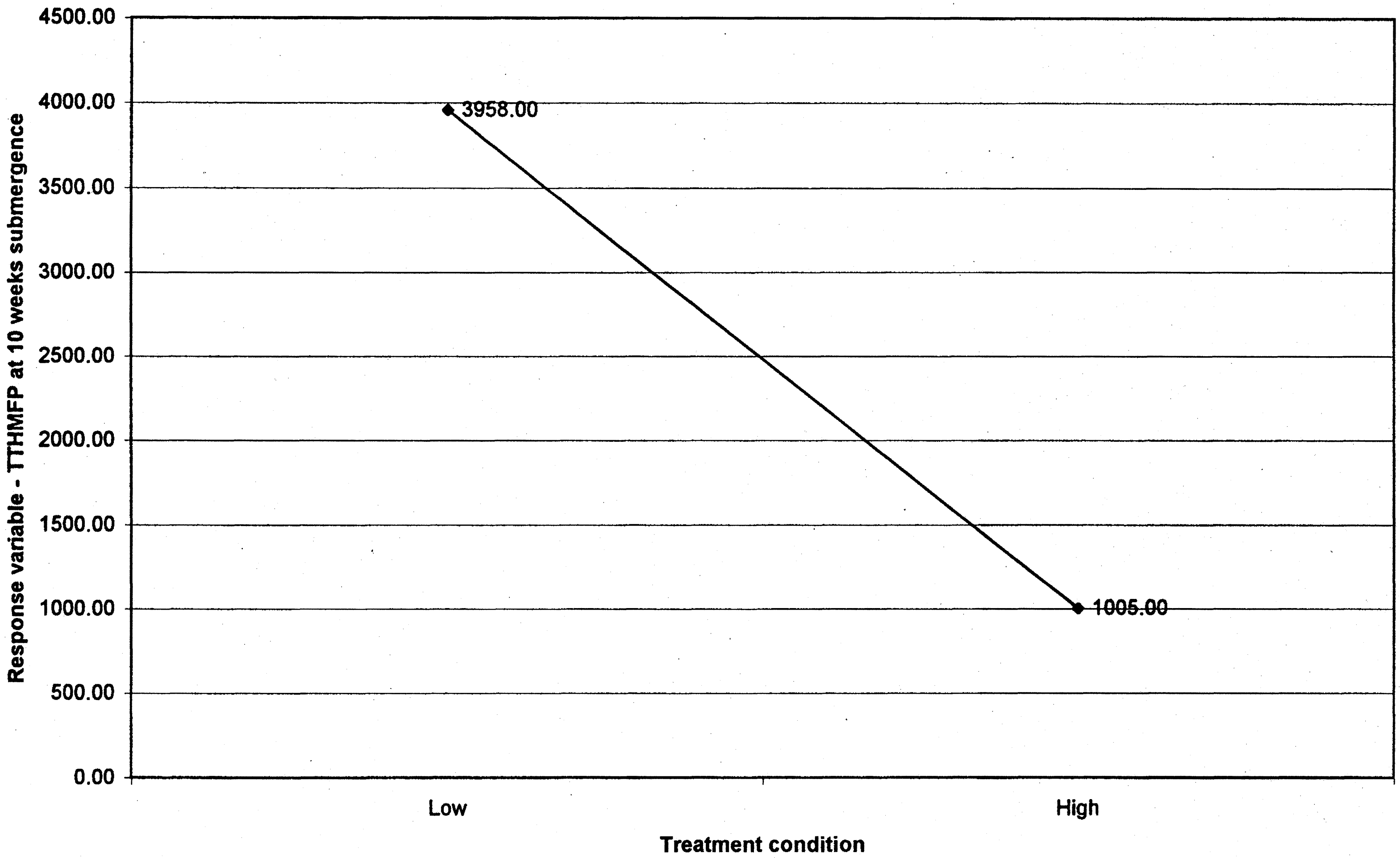


Chart 3. Factor 3 (Water Exchange) Main Effects

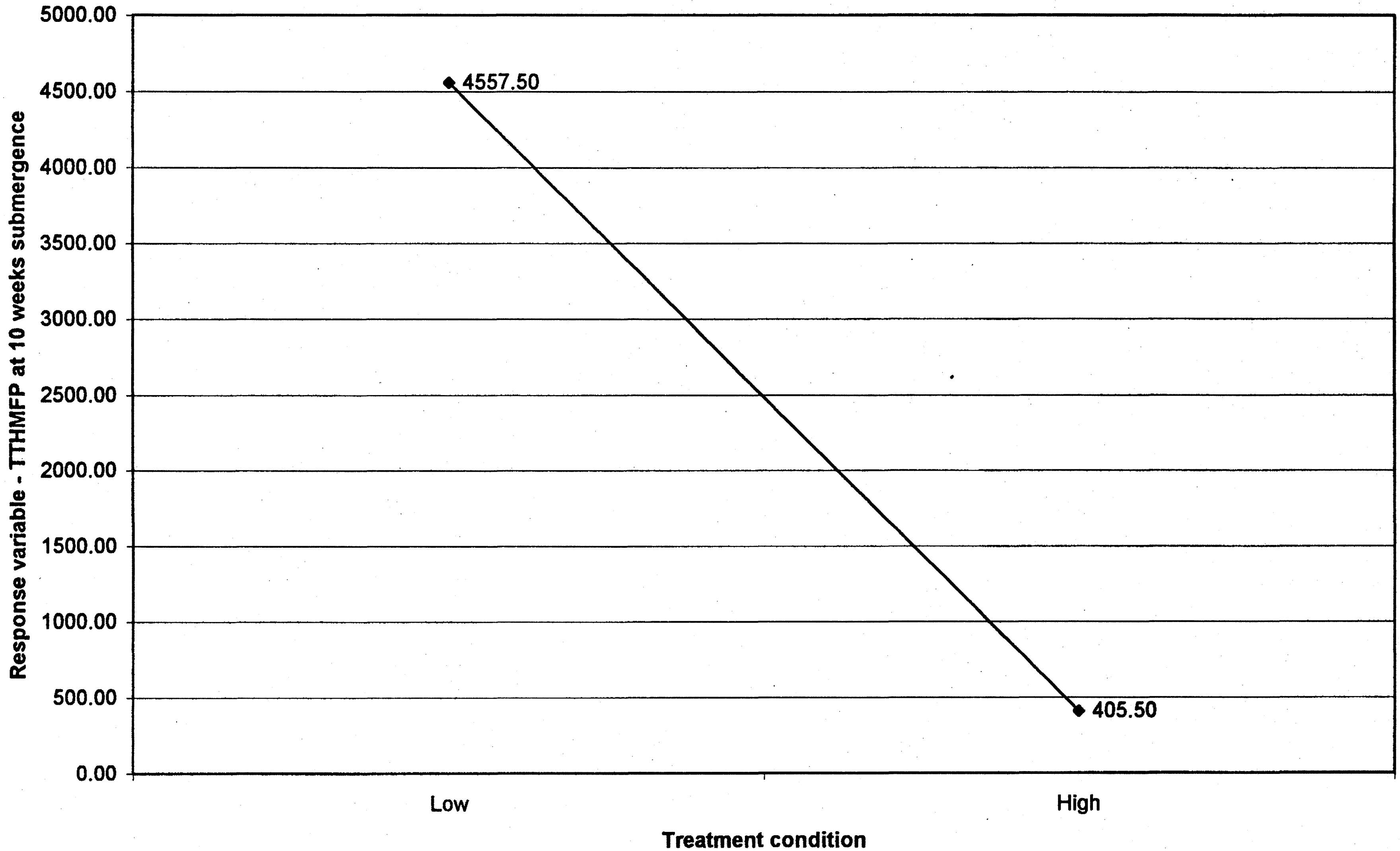


Chart 4. F1 (Peat) F2 (Water Depth) Interaction

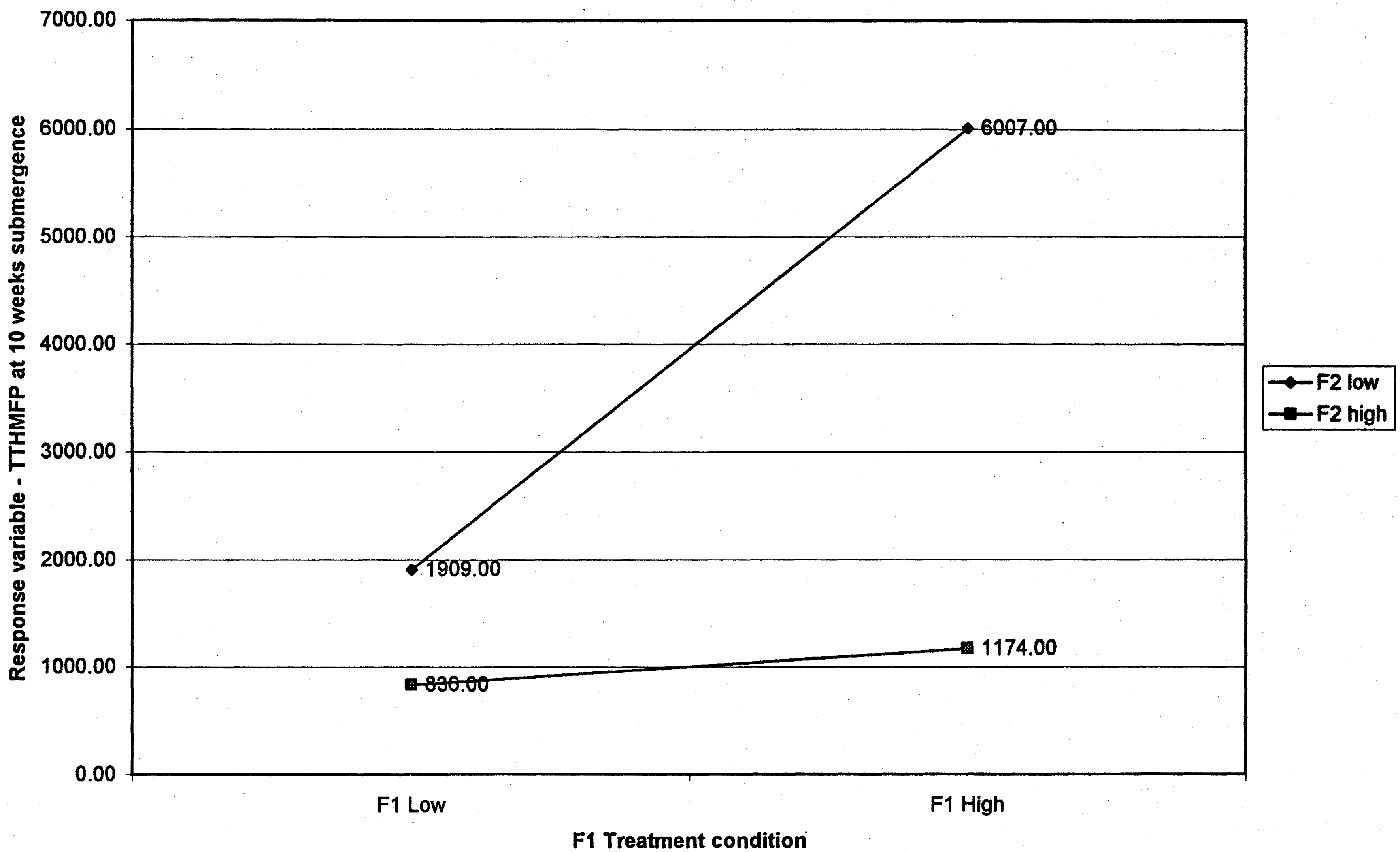


Chart 5. F1 (Peat) F3 (Water Exchange) Interaction

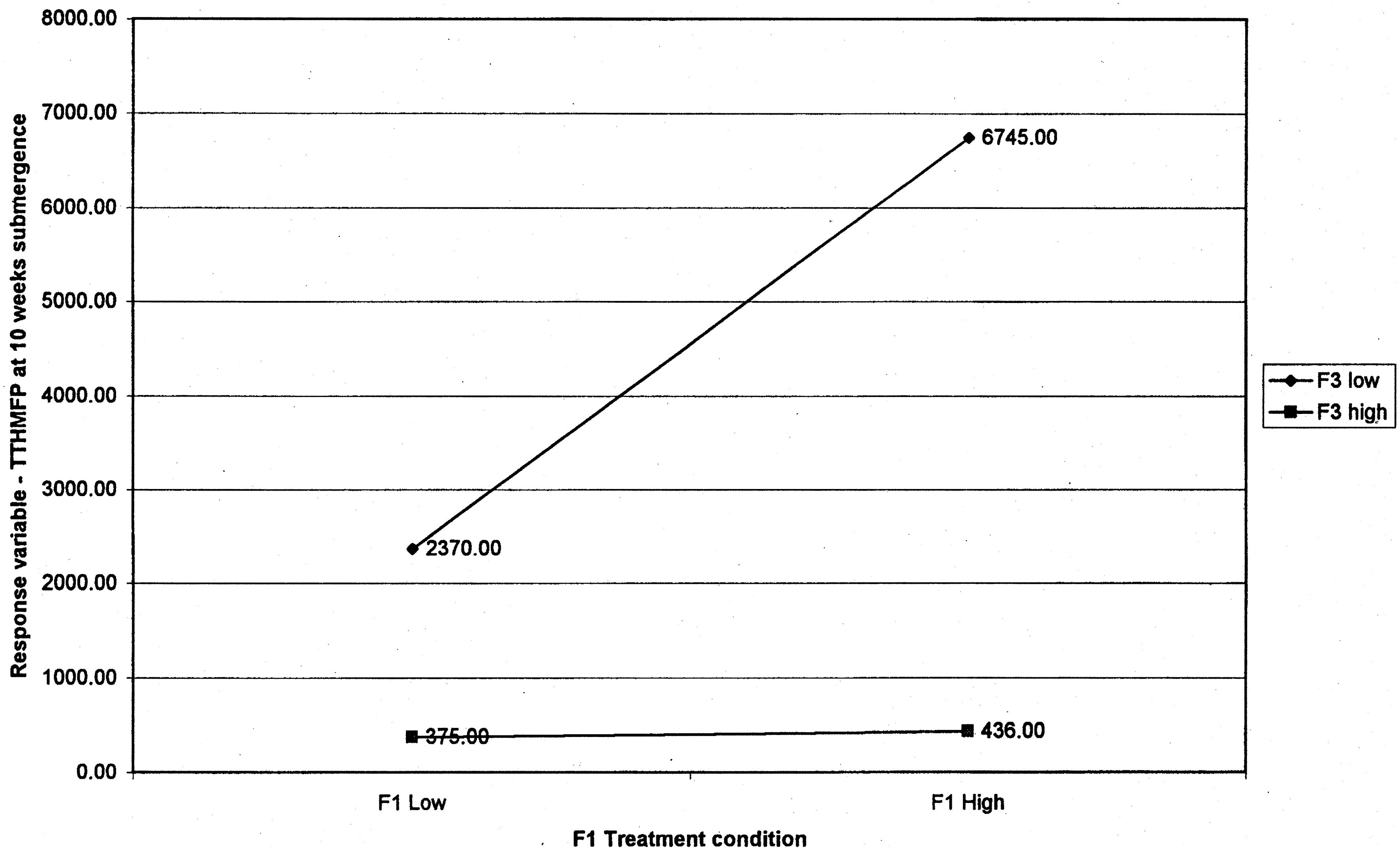
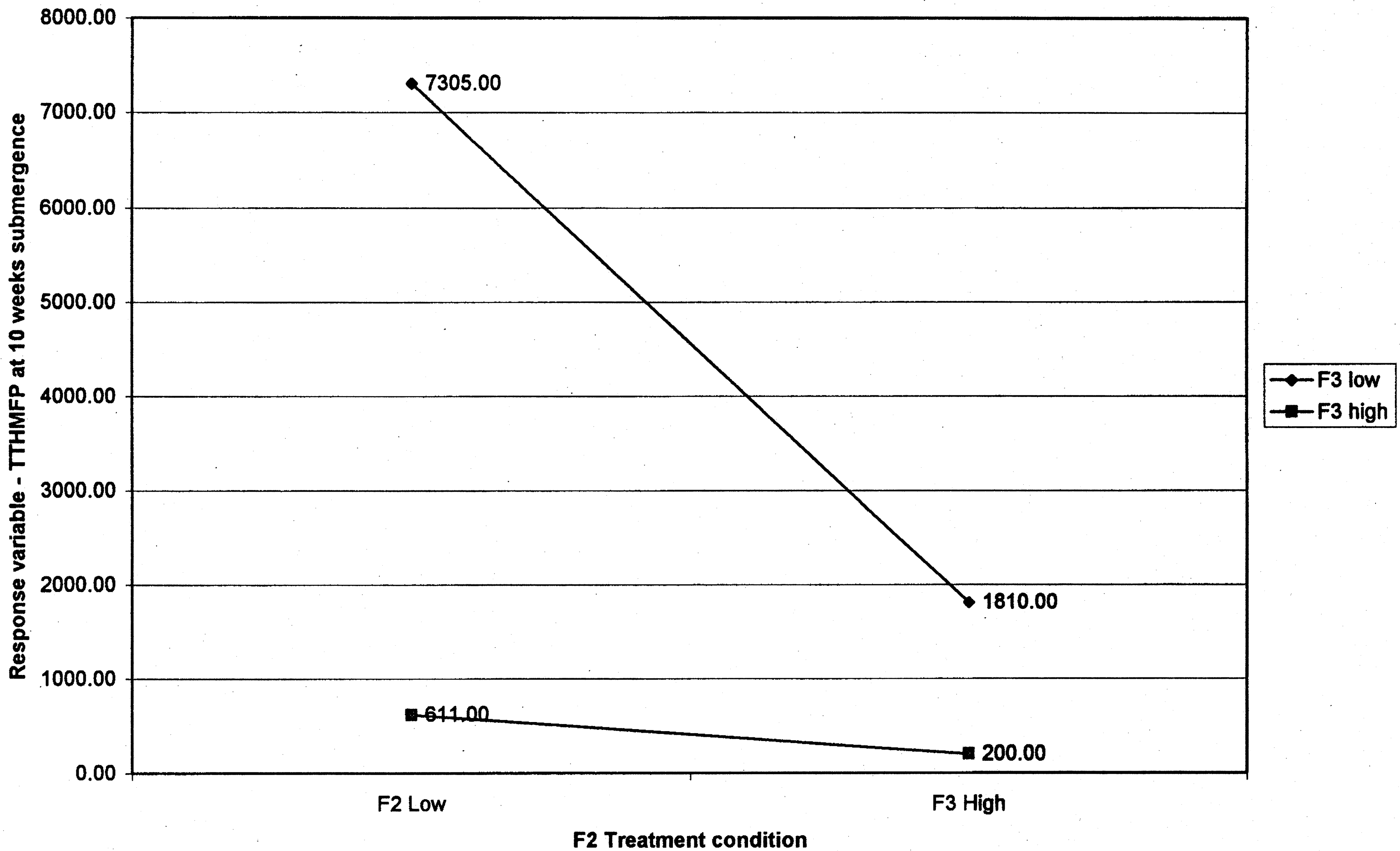


Chart 6. F2 (Water Depth) F3 (Water Exchange) Interaction



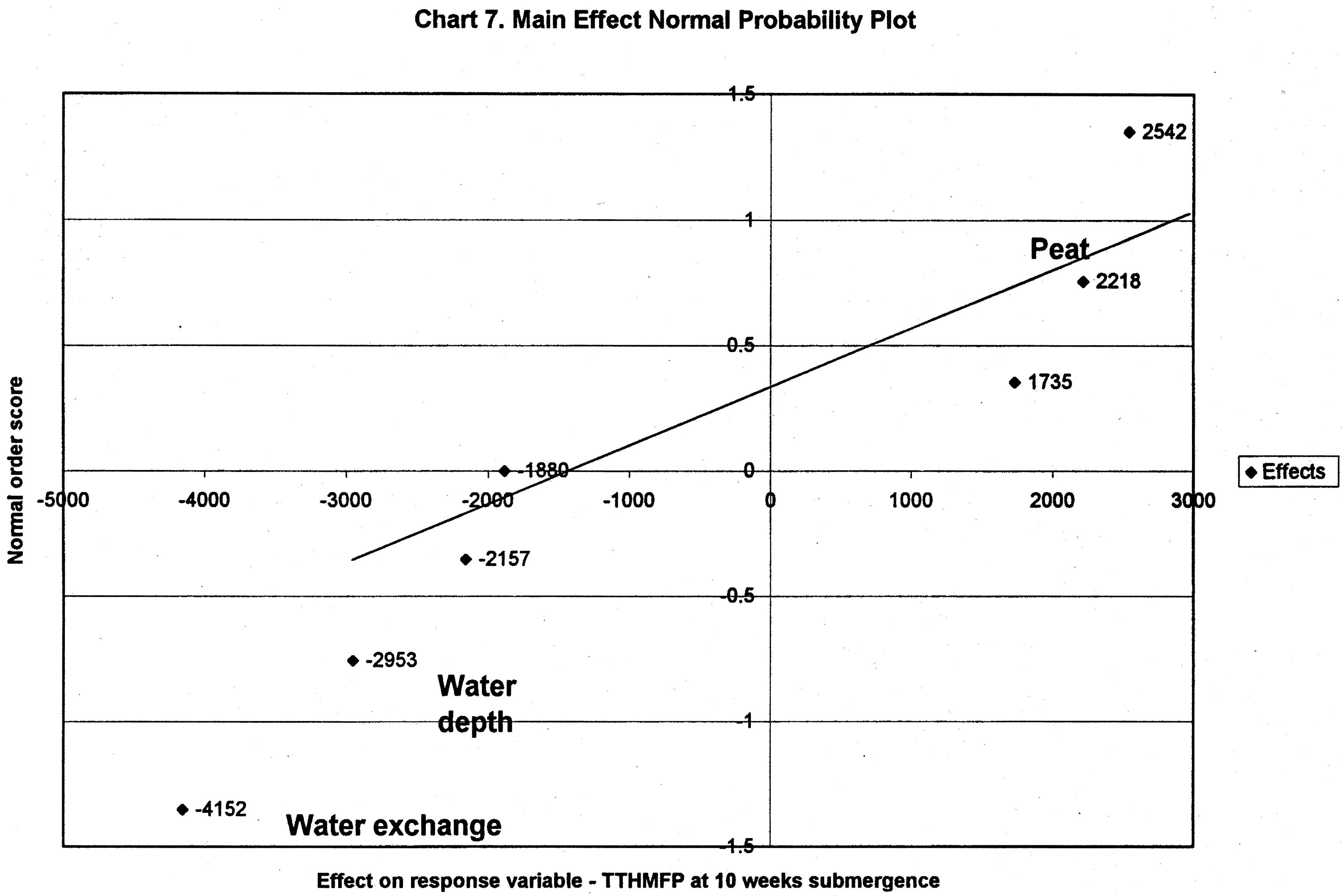


Chart 7. Main Effect Normal Probability Plot
1.5
1
0.5
0
-0.5
-1
-1.5
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
Normal order score
Effect on response variable - TTHMFP at 10 weeks submergence
2542
2218
1735
-1880
-2157
-2953
-4152
Peat
Water depth
Water exchange
Effects

Data Summary and Effects Table for Two-Cubed Factorial Experiment

SUMMARY OF EXPERIMENTAL DATA AND EFFECTS

Response variable name: EC Experiment #1 at 10 weeks submergence

Enter Response Variable in dependent variable column for each SMARTS tank designated in last column.
Factors 1, 2, and 3 in order are: peat soil depth, water depth, and water exchange rate.
Interaction effects are designated as columns 12,13, and 123.
Italicized numbers 0 and 1 designate - and + treatments (low and high) in each tank.

Runs/Factor		**1**	**2**	**3**	**12**	**13**	**23**	**123**	**Dep.Var.**	**SMARTS Tank #**
	1	***0***	***0***	***0***	***1***	***1***	***1***	***0***	***245***	**1**
	2	***1***	***0***	***0***	***0***	***0***	***1***	***1***	***532***	**3**
	3	***0***	***1***	***0***	***0***	***1***	***0***	***1***	***174***	**7**
	4	***1***	***1***	***0***	***1***	***0***	***0***	***0***	***225***	**5**
	5	***0***	***0***	***1***	***1***	***0***	***0***	***1***	***174***	**2f**
	6	***1***	***0***	***1***	***0***	***1***	***0***	***0***	***201***	**4f**
	7	***0***	***1***	***1***	***0***	***0***	***1***	***0***	***174***	**6f**
	8	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***172***	**8f**
Sum (1)		1130	745	721	816	792	1123	1052		
Sum (0)		767	1152	1176	1081	1105	774	845		
Avg (1)		282.50	186.25	180.25	204.00	198.00	280.75	263.00		
Avg (0)		191.75	288.00	294.00	270.25	276.25	193.50	211.25		
Effect		***90.75***	***-101.75***	***-113.75***	***-66.25***	***-78.25***	***87.25***	***51.75***		
Normal order score		1.352	-0.757	-1.352	0	-0.353	0.757	0.353		
Rank order		7	2	1	4	3	6	5		
P value		0.93	0.21	0.07	0.50	0.36	0.79	0.64		

Main Effects Data for Graphs

	Treatment	**Chart 1 Factor 1**	**Treatment**	**Chart 2 Factor 2**	**Treatment**	**Chart 3 Factor 3**
Avg (0)	Low	191.75	Low	288.00	Low	294.00
Avg(1)	High	282.50	High	186.25	High	180.25

Interaction Effects Data for Graphs

	Chart 4 Factors 1 and 2 Interaction F1F2			**Chart 5 Factors 1 and 3 Interaction F1F3**			**Chart 6 Factors 2 and 3 Interaction F2F3**		
		F2 Low	F2 High		F3 Low	F3 High		F3 Low	F3 High
Avg (0)	F1 Low	209.50	174.00	F1 Low	209.50	174.00	F2 Low	388.50	187.50
Avg(1)	F1 High	366.50	198.50	F1 High	378.50	186.50	F3 High	199.50	173.00

Note: If lines on chart intersect there is interaction.

Lookup table:

Chart 7 is normal plot of effects

Rank order	**Normal order score**
1	-1.352
2	-0.757
3	-0.353
4	0
5	0.353
6	0.757
7	1.352

Chart 1. Factor 1 (Peat) Main Effects

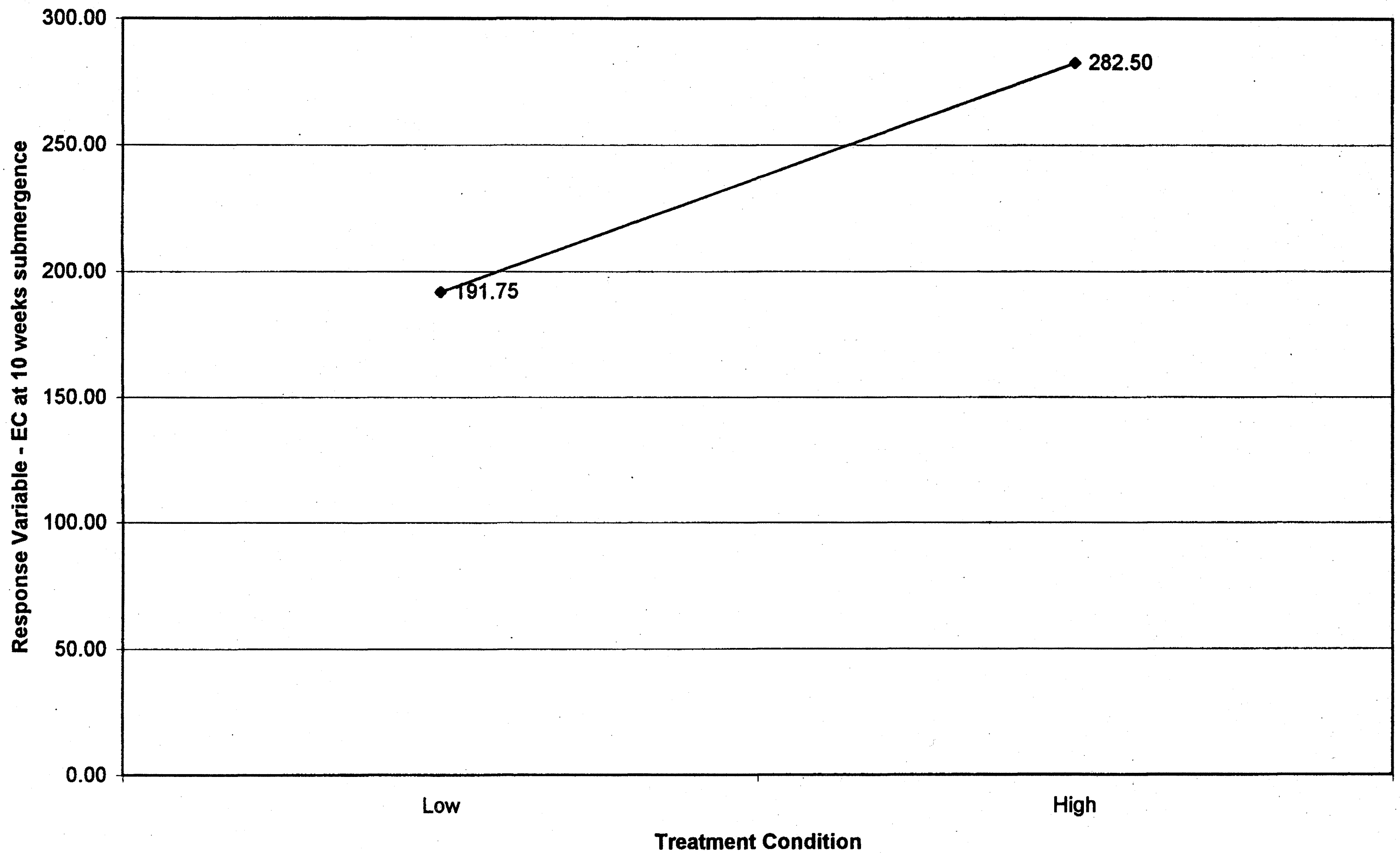


Chart 2. Factor 2 (Water Depth) Main Effects

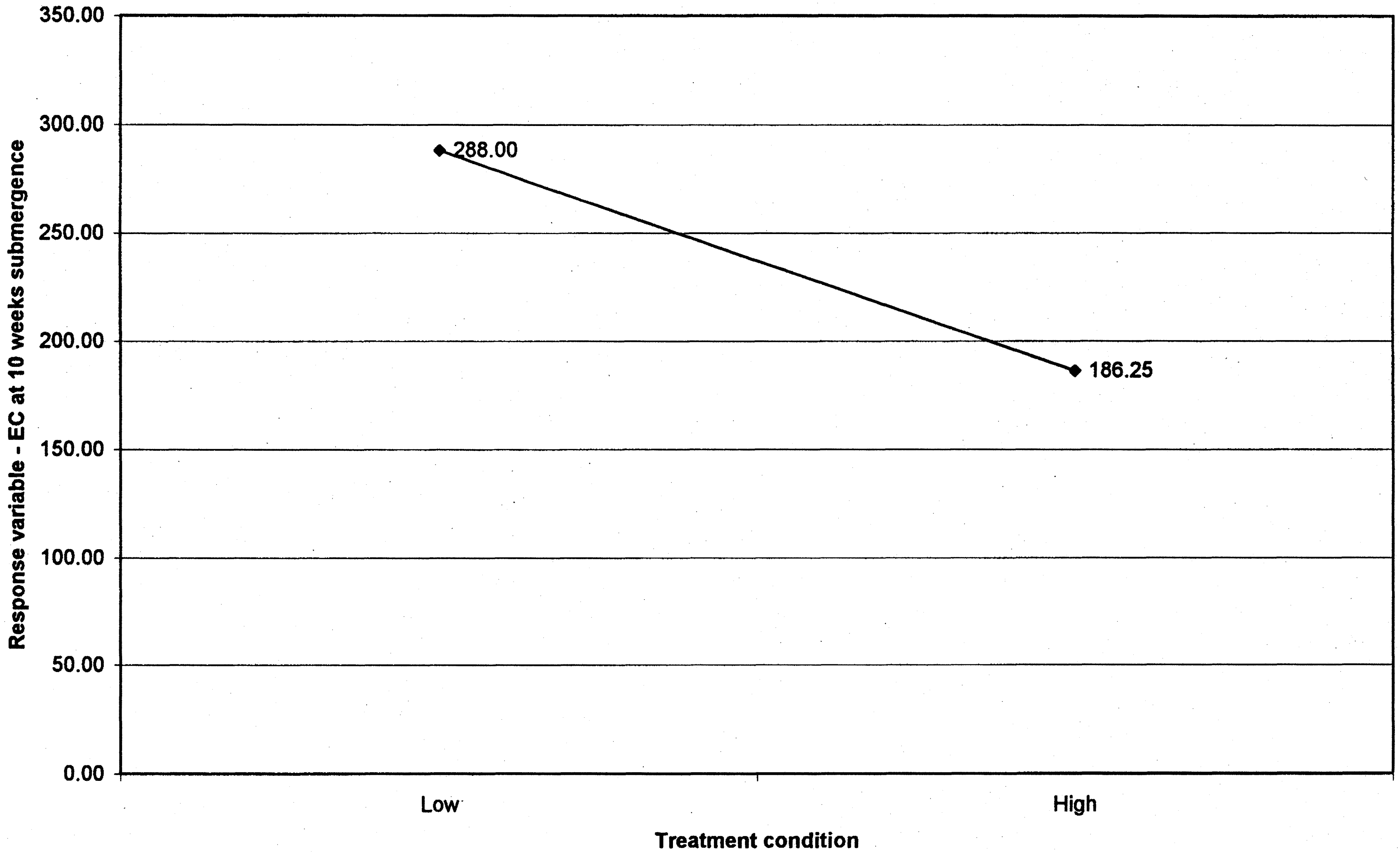


Chart 3. Factor 3 (Water Exchange) Main Effects

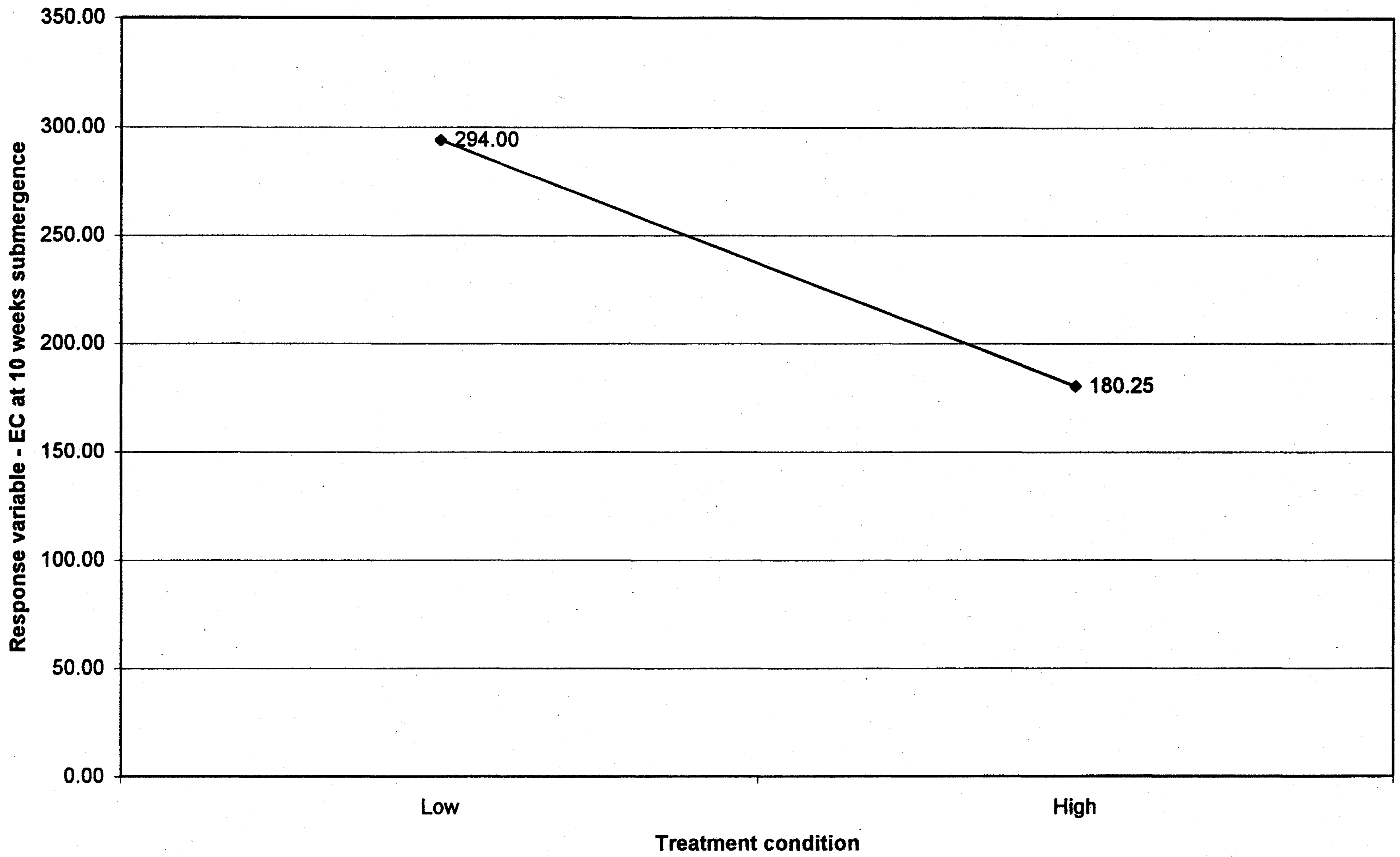


Chart 4. F1 (Peat) F2 (Water Depth) Interaction

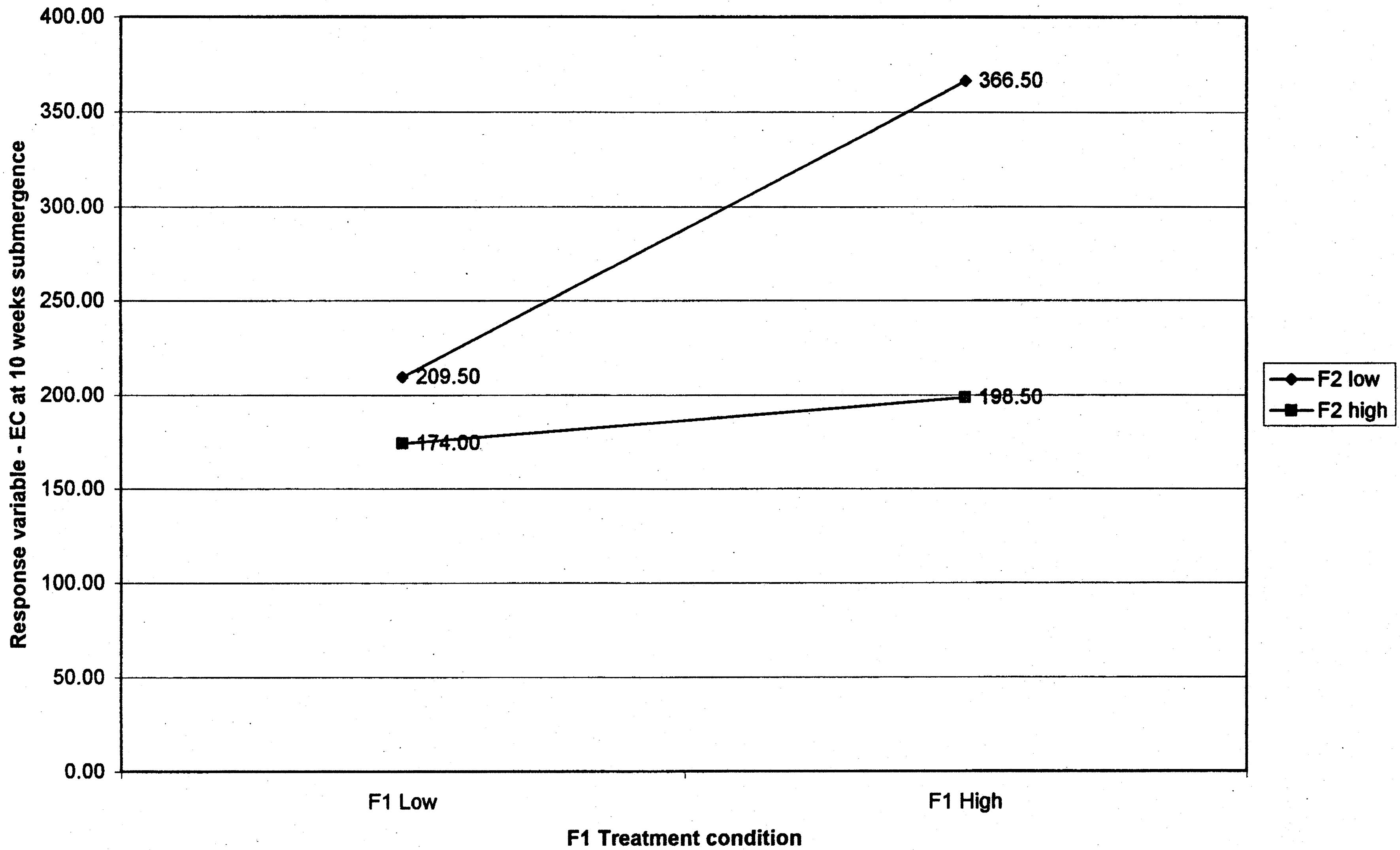


Chart 5. F1 (Peat) F3 (Water Exchange) Interaction

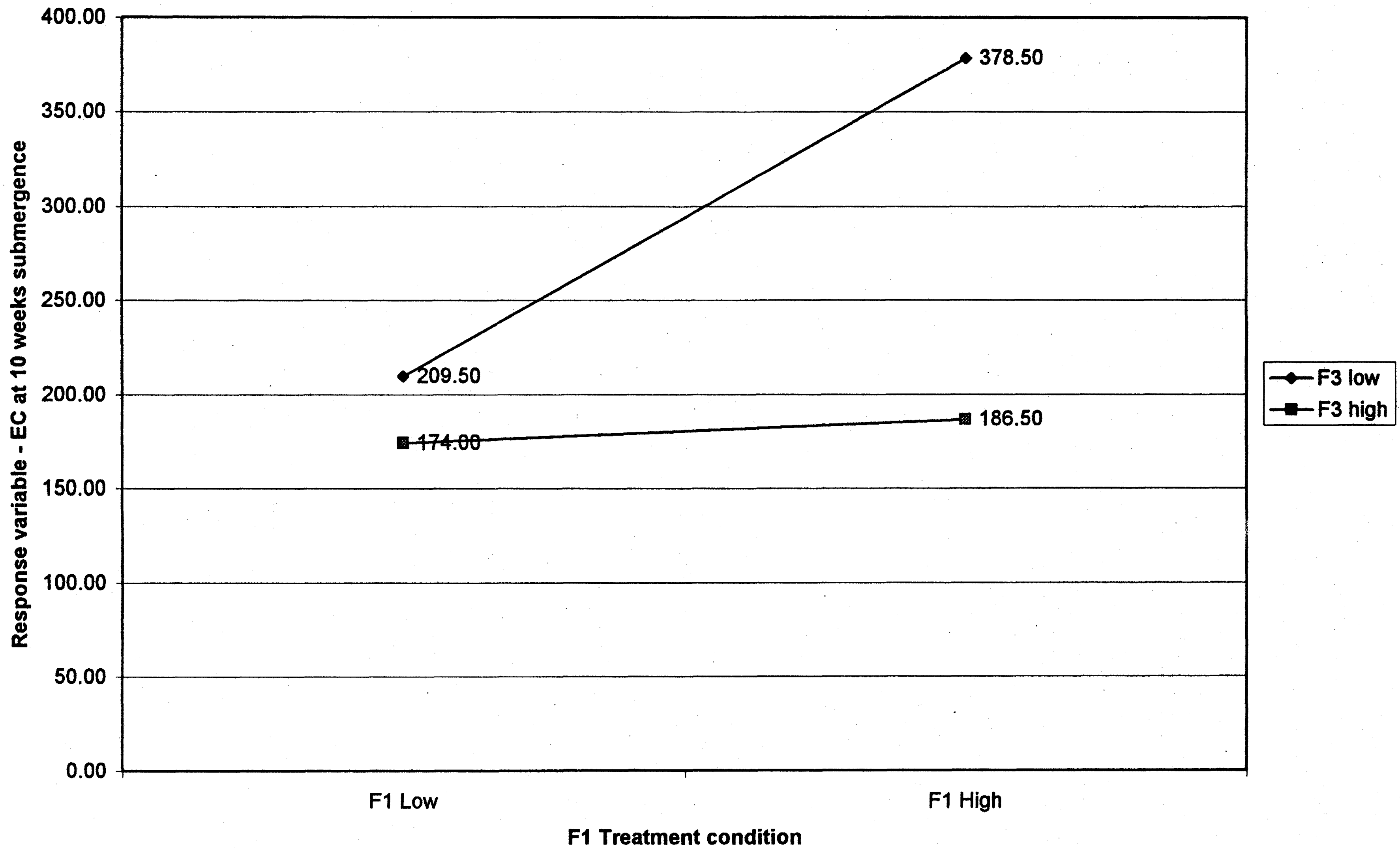


Chart 6. F2 (Water Depth) F3 (Water Exchange) Interaction

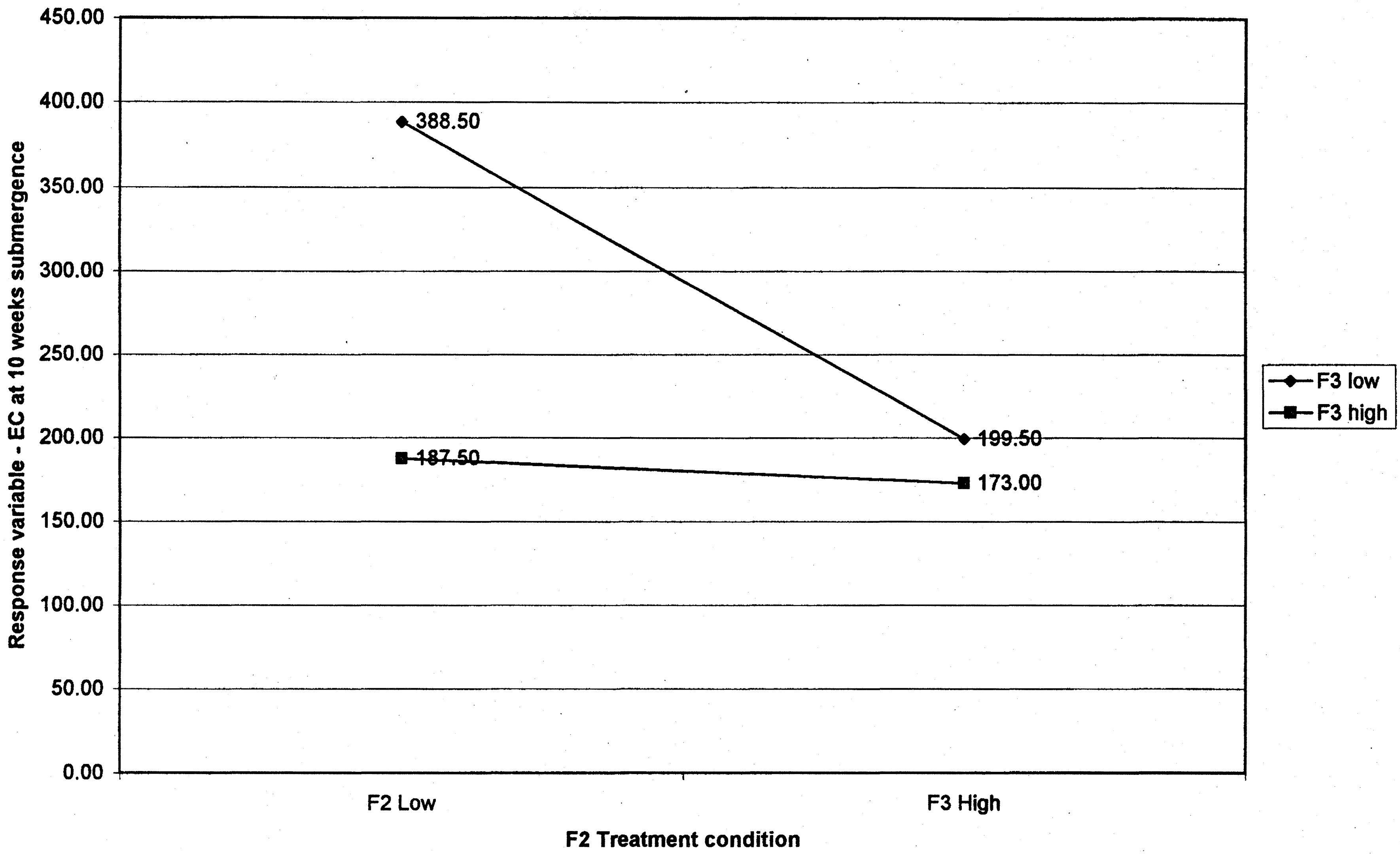
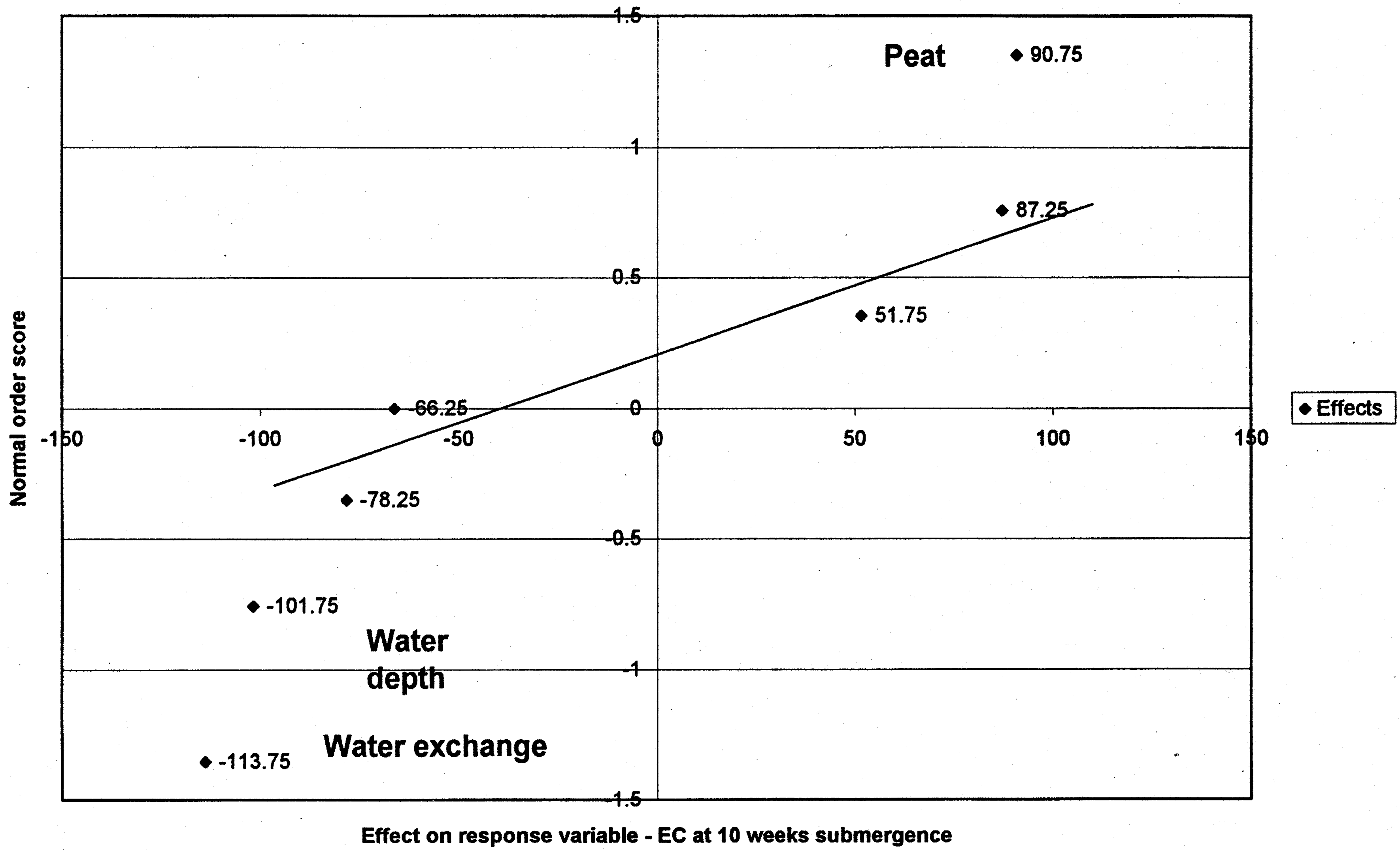


Chart 7. Main Effect Normal Probability Plot

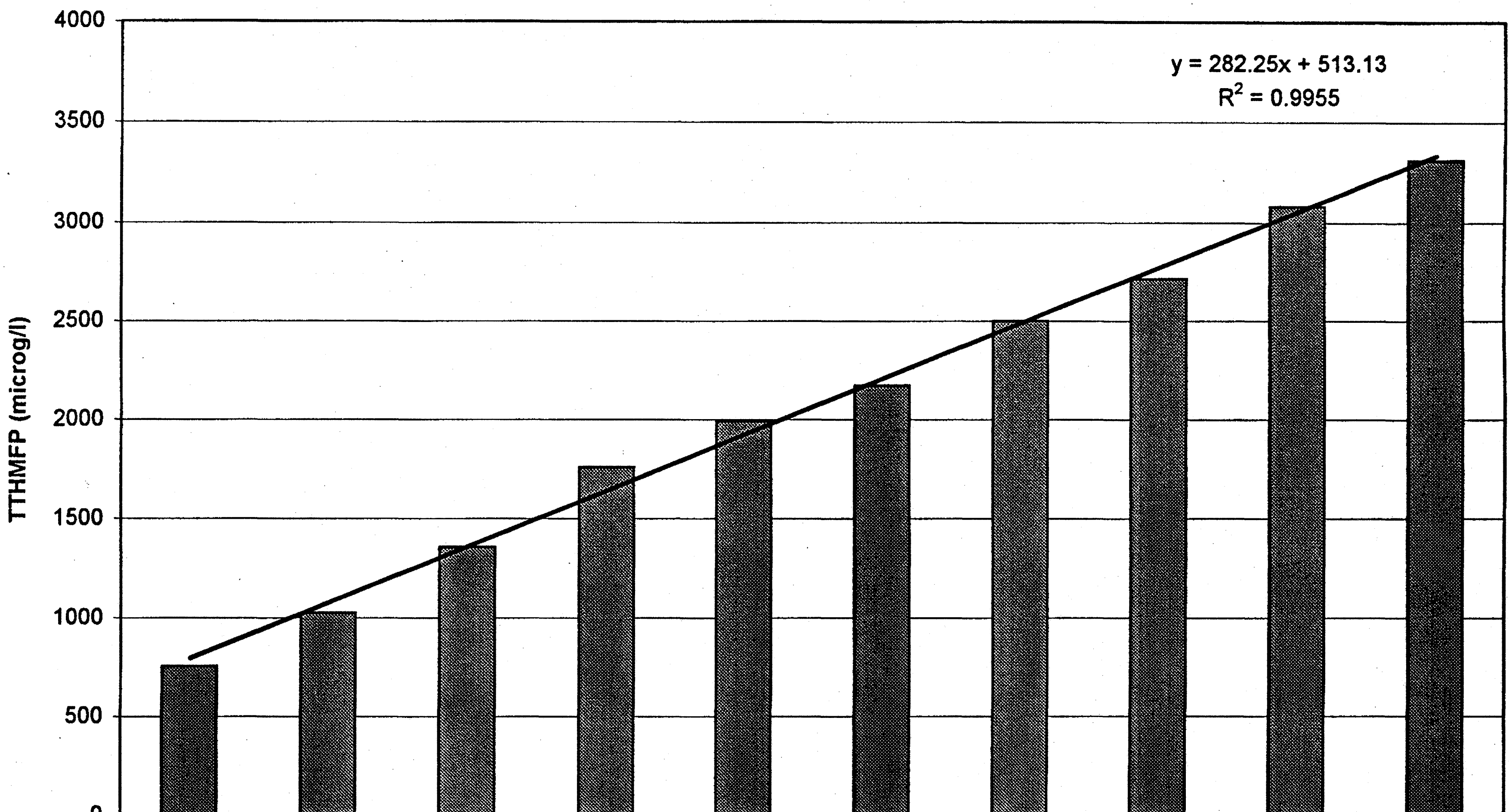


Appendix D

Rates of Water Quality Change Figures

TTHMFP Surface Water			SMARTS Experiment #1 Data - Summer 1998									
Tank/Week	1	2	3	4	5	6	7	8	9	10	11	12
1	753	1025	1355	1760	1992	2170	2500	2710	3080	3310	3060	3120
2f	872	947	885	828	730	611	635	701	617	508	332	232
3	1854	2681	3400	4820	4800	5920	7800	9000	10500	11300	6510	4940
4f	1300	1272	1500	1520	1210	948	1120	810	768	714	496	524
5	540	724	900	1147	1376	1380	1620	1740	2040	2190	2310	2420
6f	640	434	338	395	322	287	246	261	240	242	173	150
7	382	510	625	767	939	964	1053	1110	1310	1430	1550	1320
8f	290	231	192	195	185	163	175	177	189	158	156	122
9	85	80	81	79	80	77	93	98	130	130	160	150
TOC Surface Water												
Tank/Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	**11.4**	**11.4**	**15.7**	**21.5**	**24.7**	**26.6**	**31.3**	**30.8**	**36.6**	**38.0**	**41.5**	**41.2**
2f	**10.1**	**10.6**	**11.2**	**9.9**	**9.6**	**8.2**	**7.9**	**8.1**	**7.4**	**6.2**	**4.1**	**3.6**
3	**26.2**	**32.6**	**46.3**	**64.9**	**76.7**	**86.0**	**108.0**	**124.0**	**152.0**	**166.0**	**99.1**	**90.2**
4f	**17.5**	**15.5**	**22.3**	**20.9**	**16.5**	**12.2**	**15.1**	**11.7**	**10.0**	**8.3**	**6.3**	**7.6**
5	**6.7**	**8.6**	**10.8**	**13.6**	**17.0**	**19.6**	**21.1**	**24.6**	**26.2**	**33.3**	**28.9**	**28.5**
6f	**8.2**	**5.4**	**4.2**	**5.2**	**5.0**	**3.8**	**3.2**	**3.6**	**3.2**	**3.0**	**2.5**	**2.0**
7	**5.1**	**5.9**	**7.5**	**8.9**	**12.7**	**12.1**	**12.1**	**14.2**	**15.7**	**17.7**	**18.7**	**17.3**
8f	**3.9**	**2.8**	**2.5**	**2.8**	**2.7**	**2.6**	**2.3**	**2.9**	**2.6**	**2.3**	**2.3**	**2.4**
9	**1.2**	**1.9**	**1.6**	**1.7**	**2.0**	**2.0**	**2.4**	**3.3**	**3.2**	**3.8**	**3.7**	**4.4**
DOC (mg/l) Surface Water												
Tank/Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	**8.0**	**11.3**	**15.1**	**20.2**	**23.3**	**25.0**	**29.8**	**31.9**	**34.8**	**39.4**	**39.8**	**40.3**
2f	**9.7**	**10.4**	**10.7**	**9.6**	**9.0**	**7.5**	**7.3**	**7.6**	**6.7**	**5.2**	**3.6**	**3.6**
3	**23.3**	**31.0**	**42.6**	**59.2**	**72.7**	**82.6**	**98.7**	**114.0**	**135.0**	**108.0**	**92.4**	**87.9**
4f	**17.6**	**14.8**	**19.1**	**18.4**	**15.0**	**11.5**	**13.8**	**10.7**	**9.2**	**8.3**	**5.8**	**7.4**
5	**6.3**	**8.4**	**9.9**	**12.8**	**15.9**	**17.7**	**19.6**	**19.4**	**24.3**	**26.0**	**27.2**	**26.4**
6f	**8.1**	**5.0**	**3.8**	**4.6**	**3.8**	**3.4**	**2.8**	**3.3**	**3.0**	**2.8**	**2.1**	**1.9**
7	**5.0**	**5.9**	**6.9**	**8.5**	**10.5**	**11.0**	**11.5**	**13.6**	**14.8**	**16.5**	**18.5**	**16.0**
8f	**3.5**	**2.8**	**2.2**	**2.4**	**2.4**	**2.3**	**2.2**	**2.3**	**2.3**	**1.9**	**2.0**	**1.8**
9	**1.6**	**1.5**	**1.4**	**1.7**	**1.8**	**1.7**	**1.7**	**2.2**	**2.3**	**2.4**	**2.5**	**2.4**

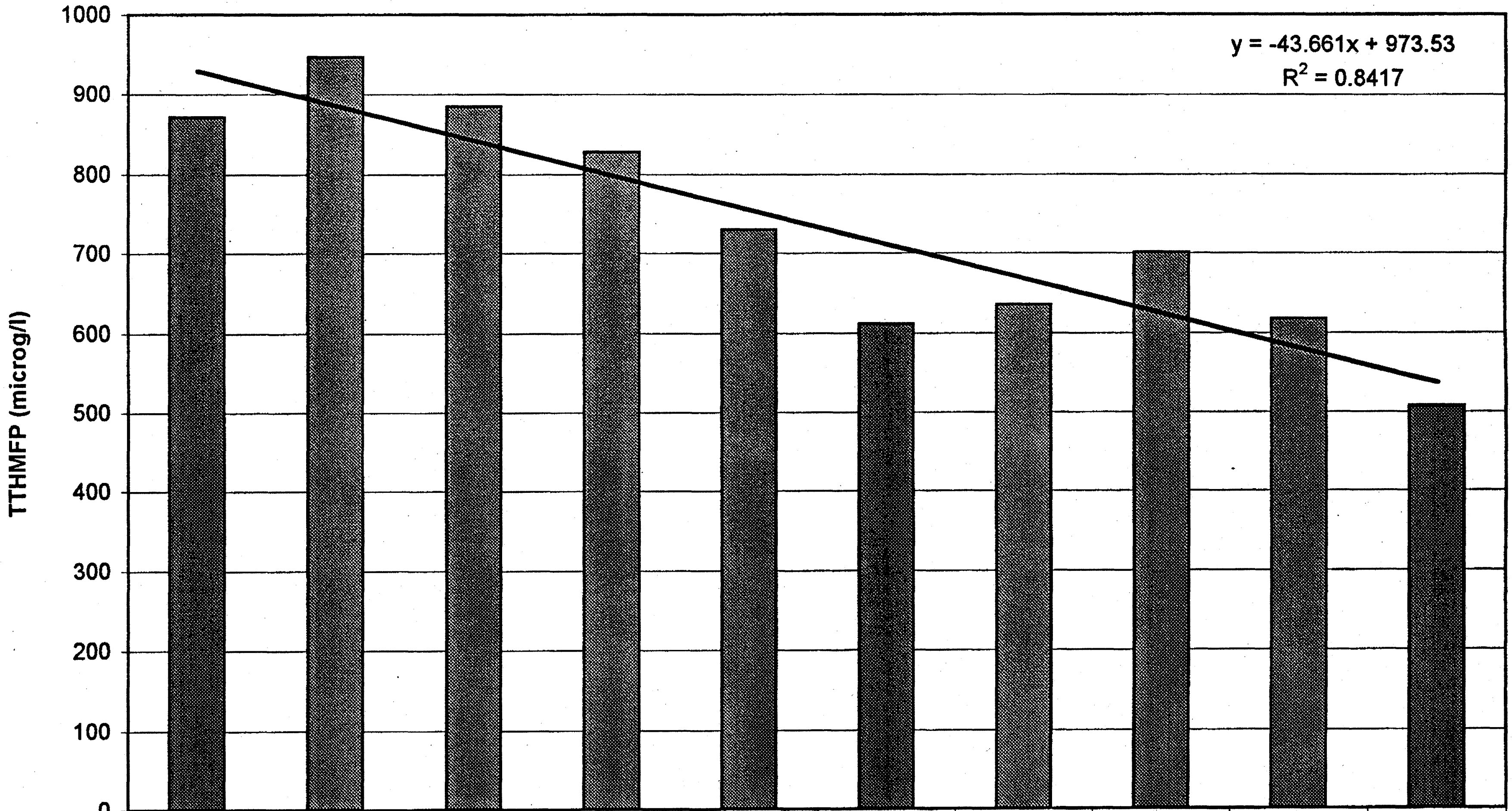
Tank 1 Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 1	753	1025	1355	1760	1992	2170	2500	2710	3080	3310

Weeks Submerged

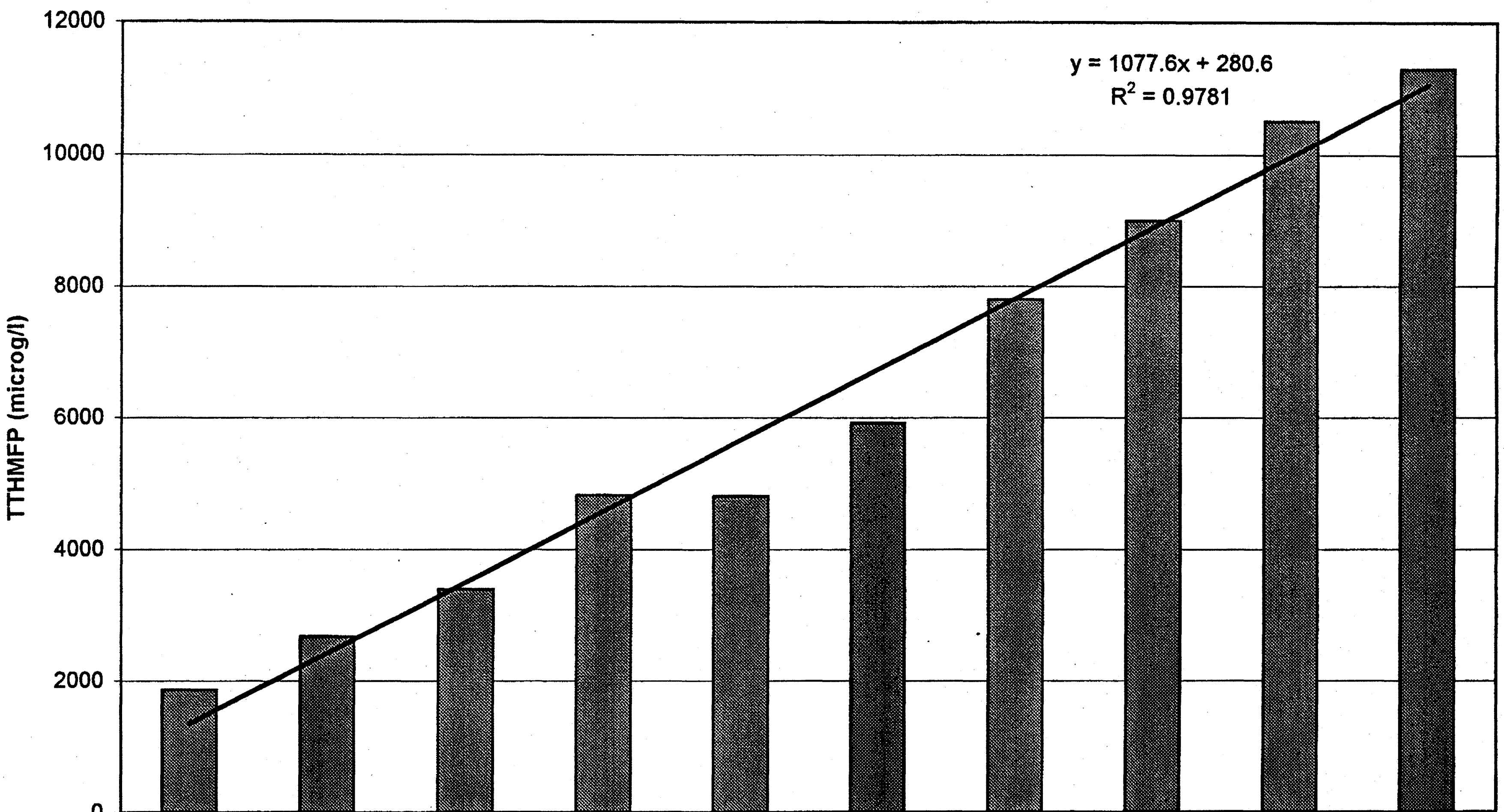
Tank 2f Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 2f	872	947	885	828	730	611	635	701	617	508

Weeks Submerged

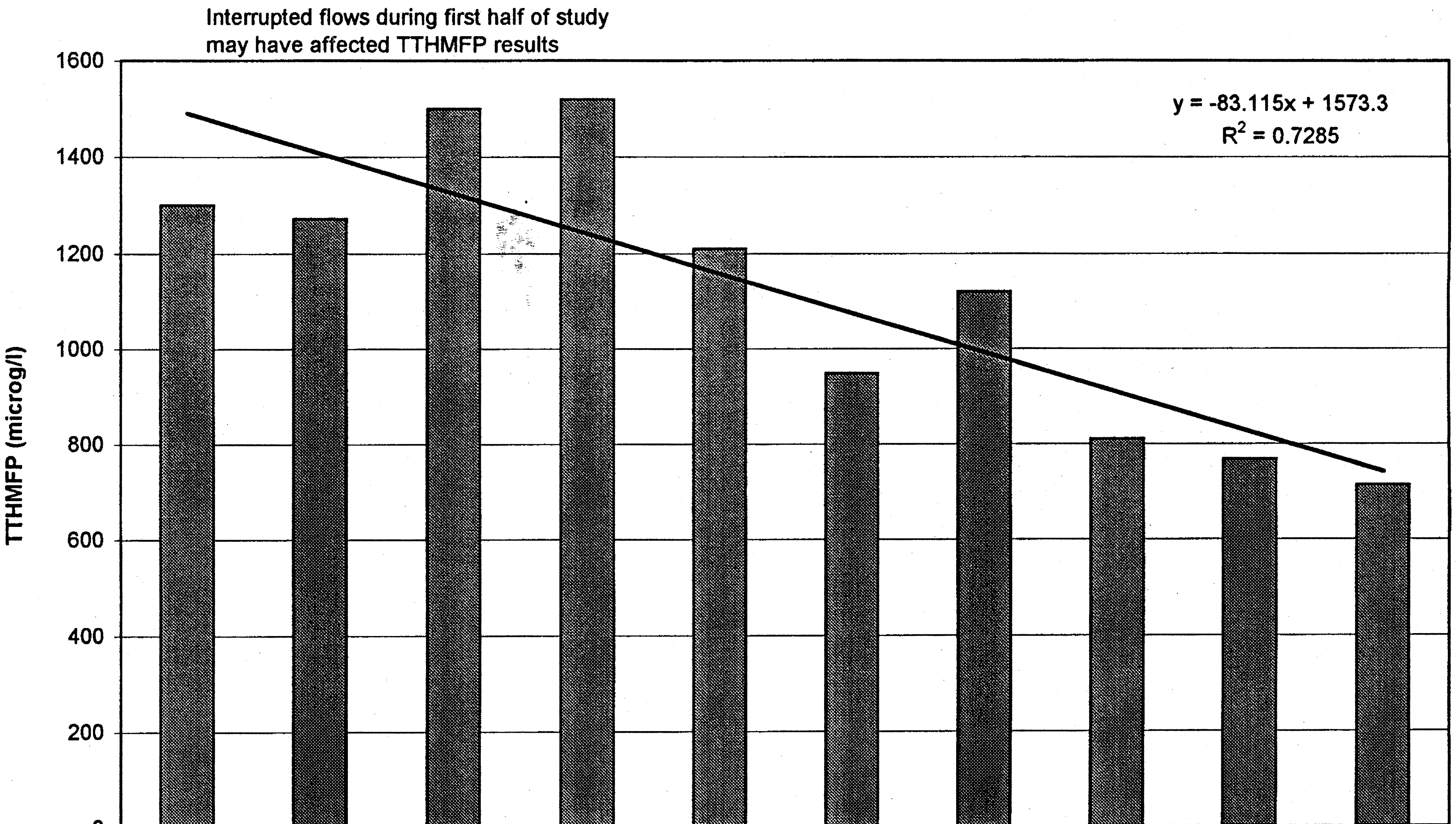
Tank 3 Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 3	1854	2681	3400	4820	4800	5920	7800	9000	10500	11300

Weeks Submerged

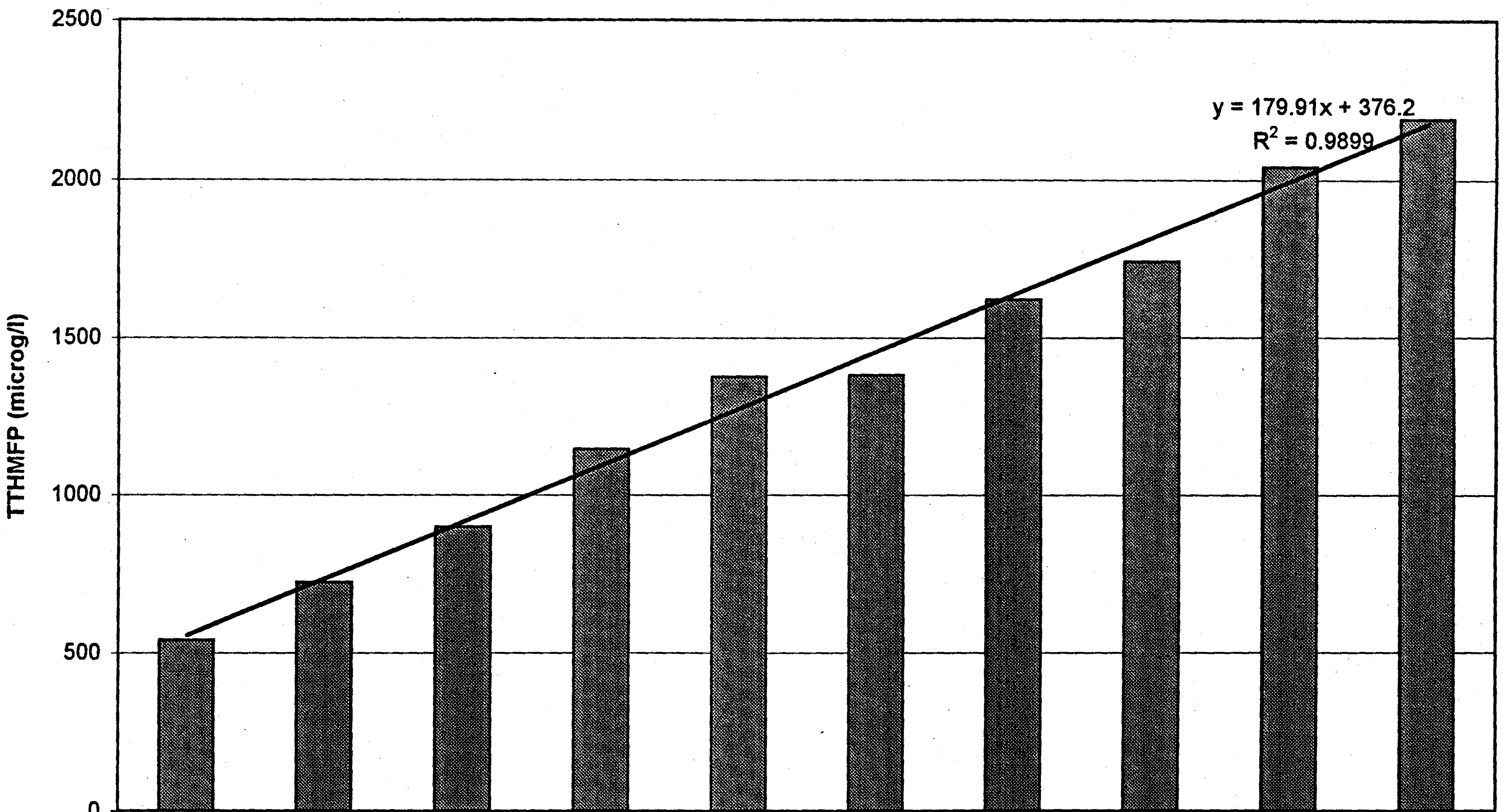
Tank 4f Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 4f	1300	1272	1500	1520	1210	948	1120	810	768	714

Weeks Submerged

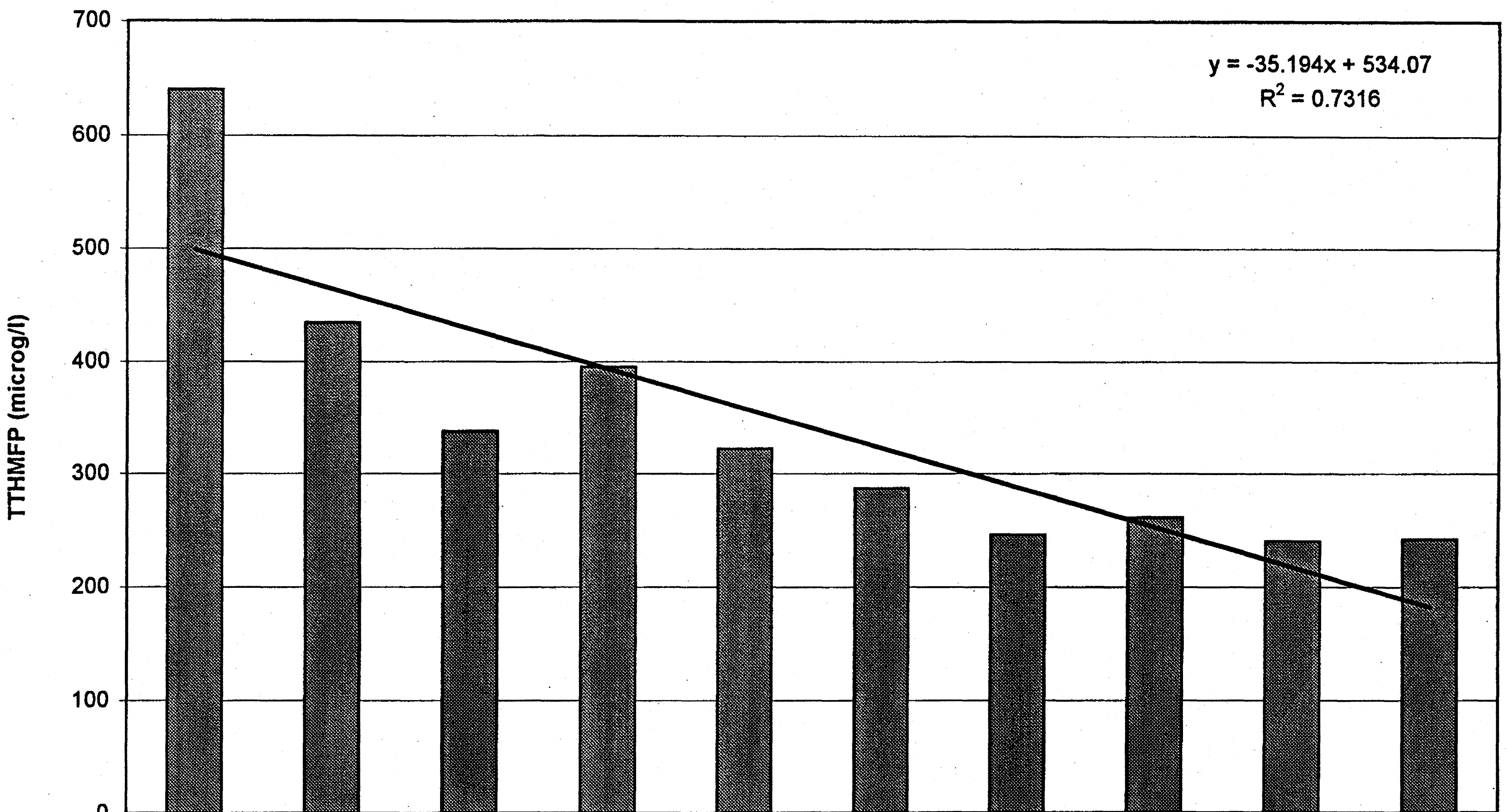
Tank 5 Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 5	540	724	900	1147	1376	1380	1620	1740	2040	2190

Weeks Submerged

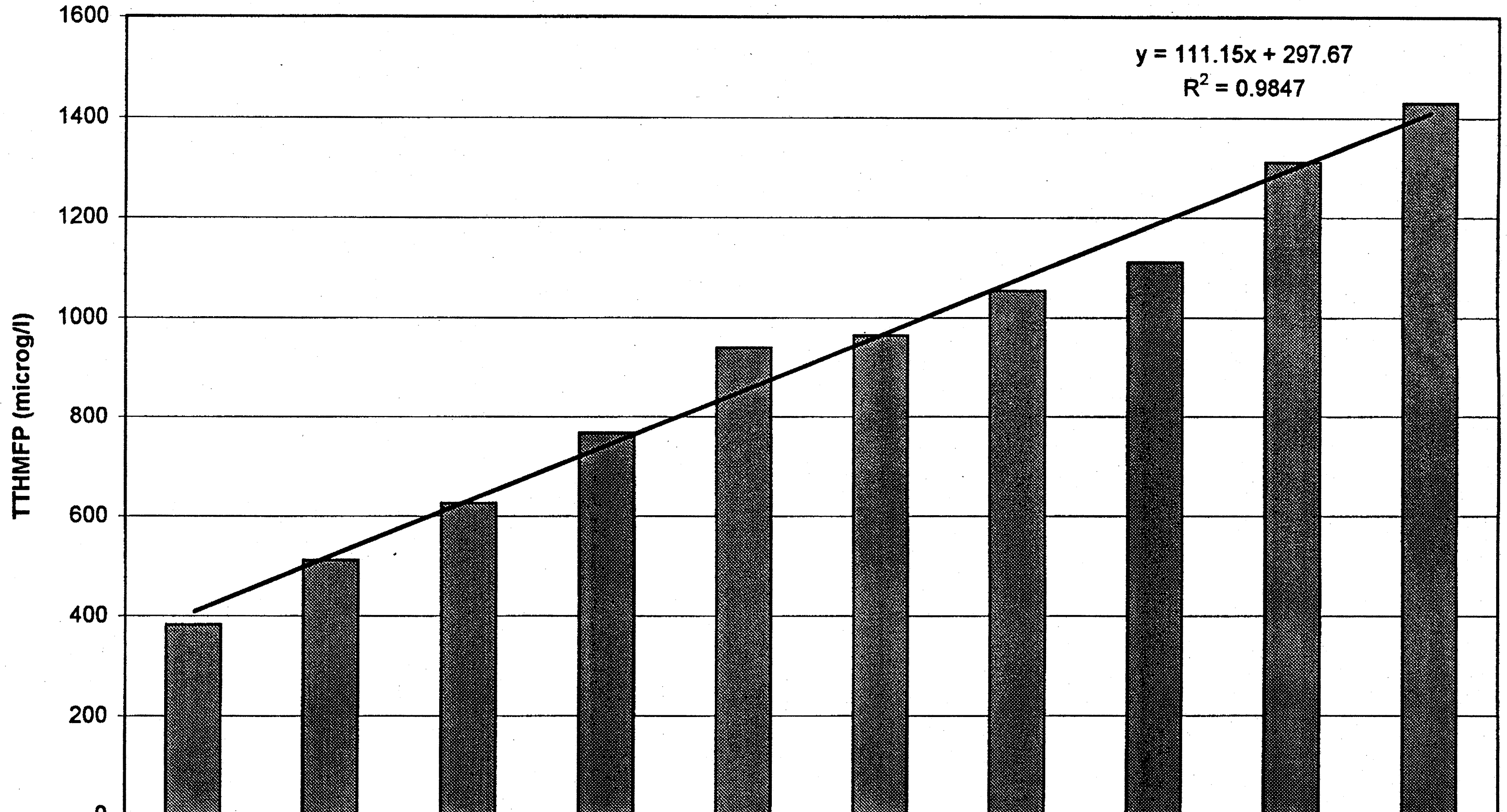
Tank 6f Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 6f	640	434	338	395	322	287	246	261	240	242

Weeks Submerged

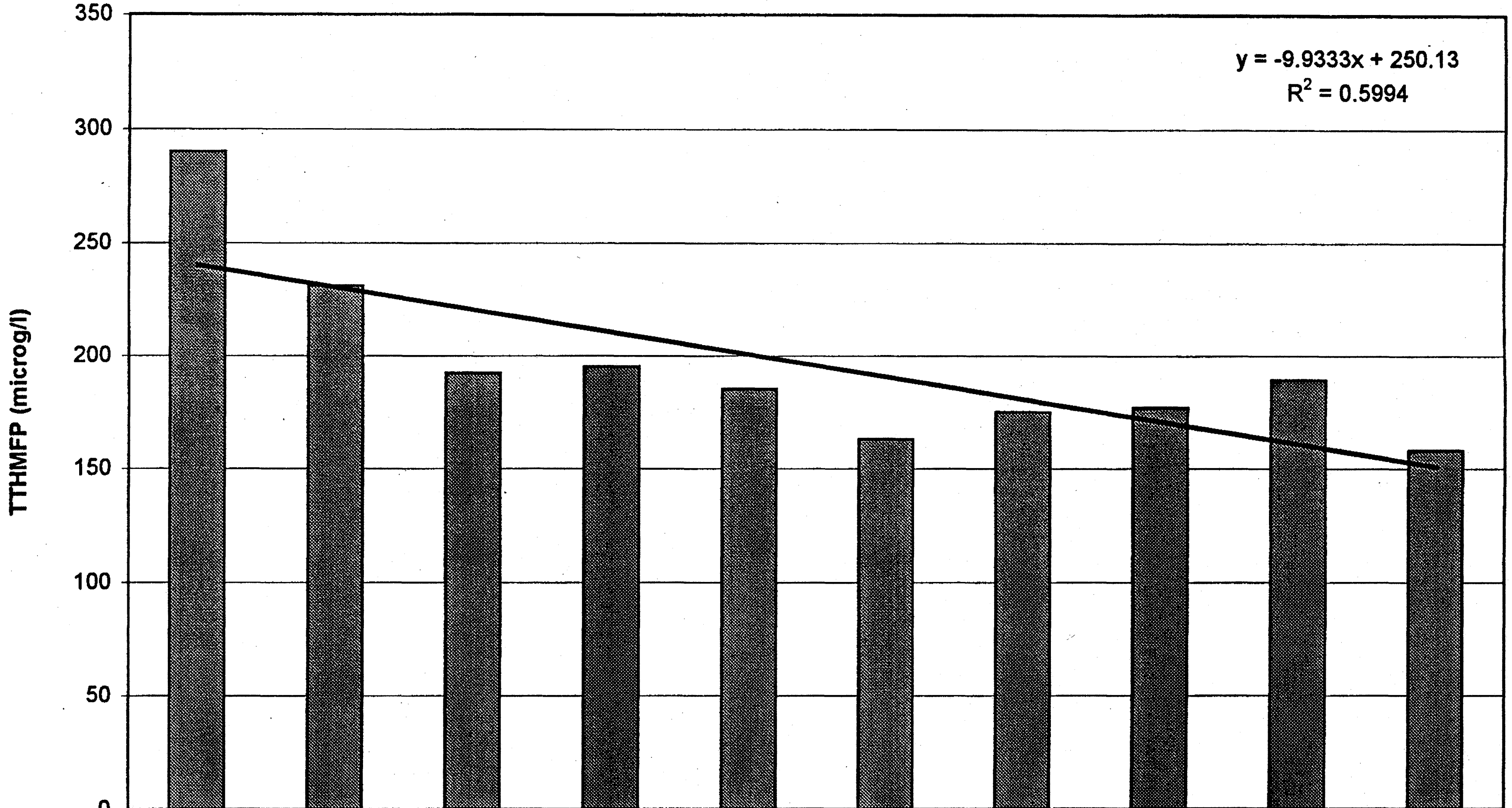
Tank 7 Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 7	382	510	625	767	939	964	1053	1110	1310	1430

Weeks Submerged

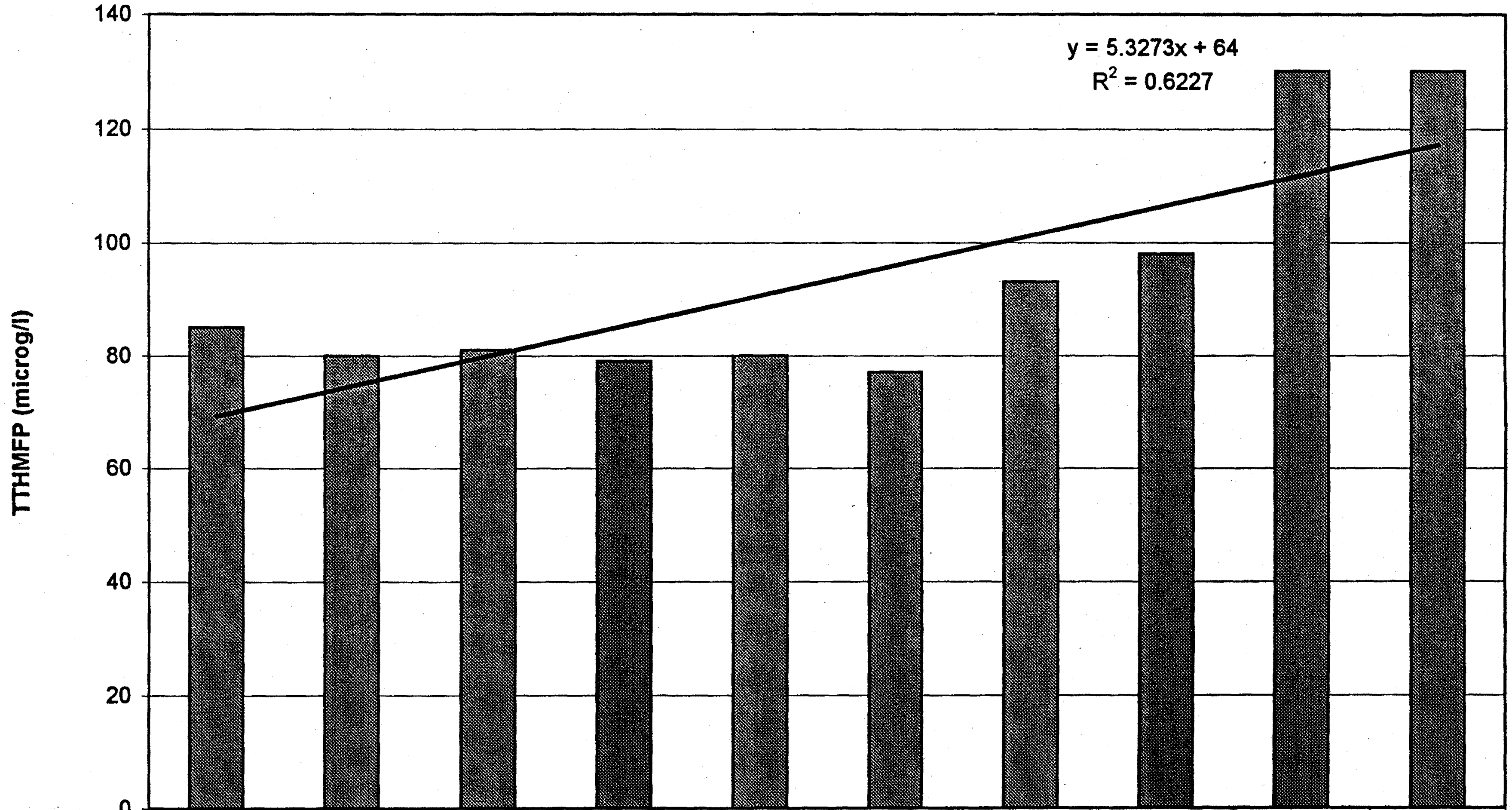
Tank 8f Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 8f	290	231	192	195	185	163	175	177	189	158

Weeks Submerged

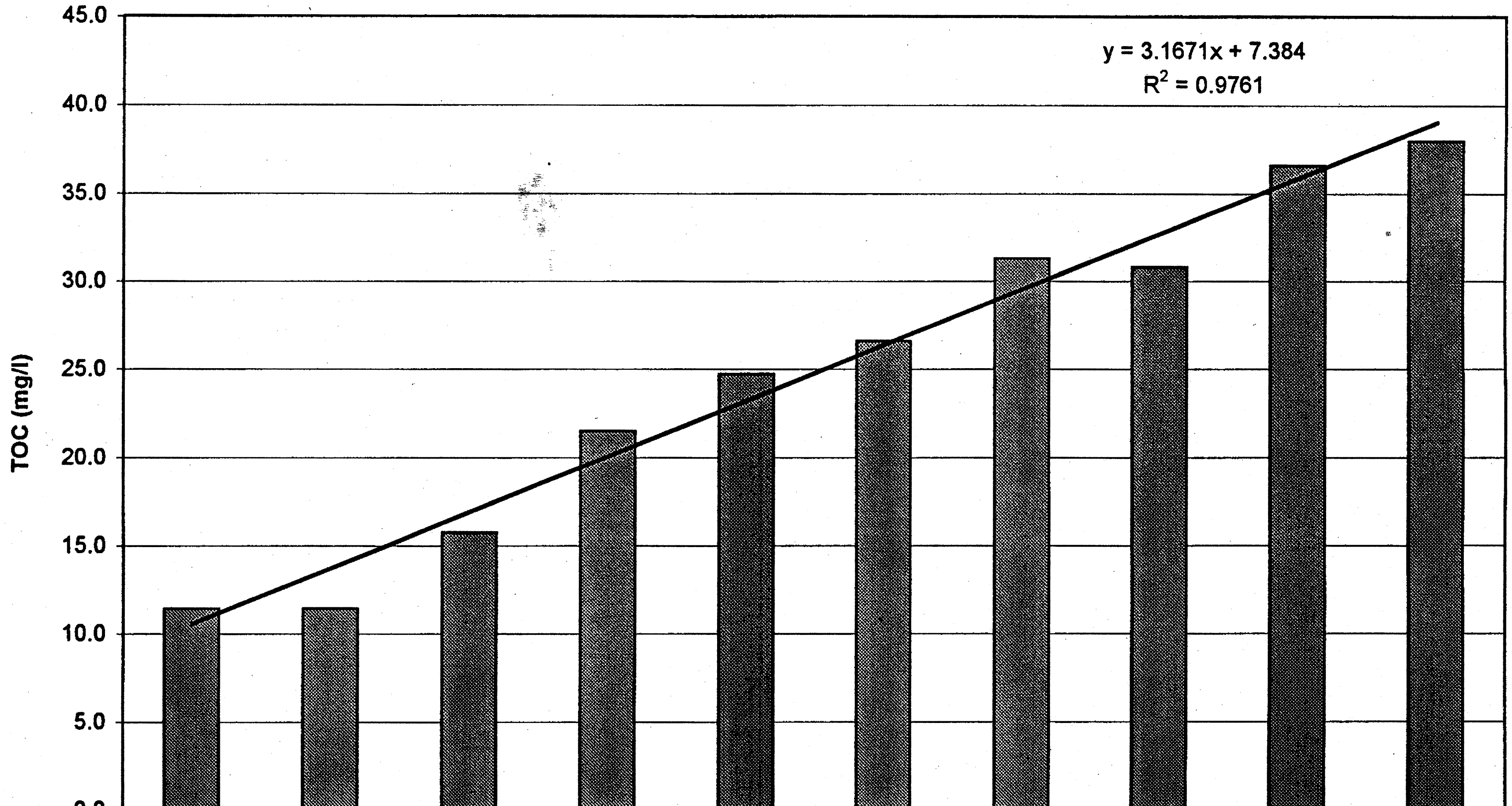
Tank 9 Surface Water TTHMFP



	1	2	3	4	5	6	7	8	9	10
Tank 9	85	80	81	79	80	77	93	98	130	130

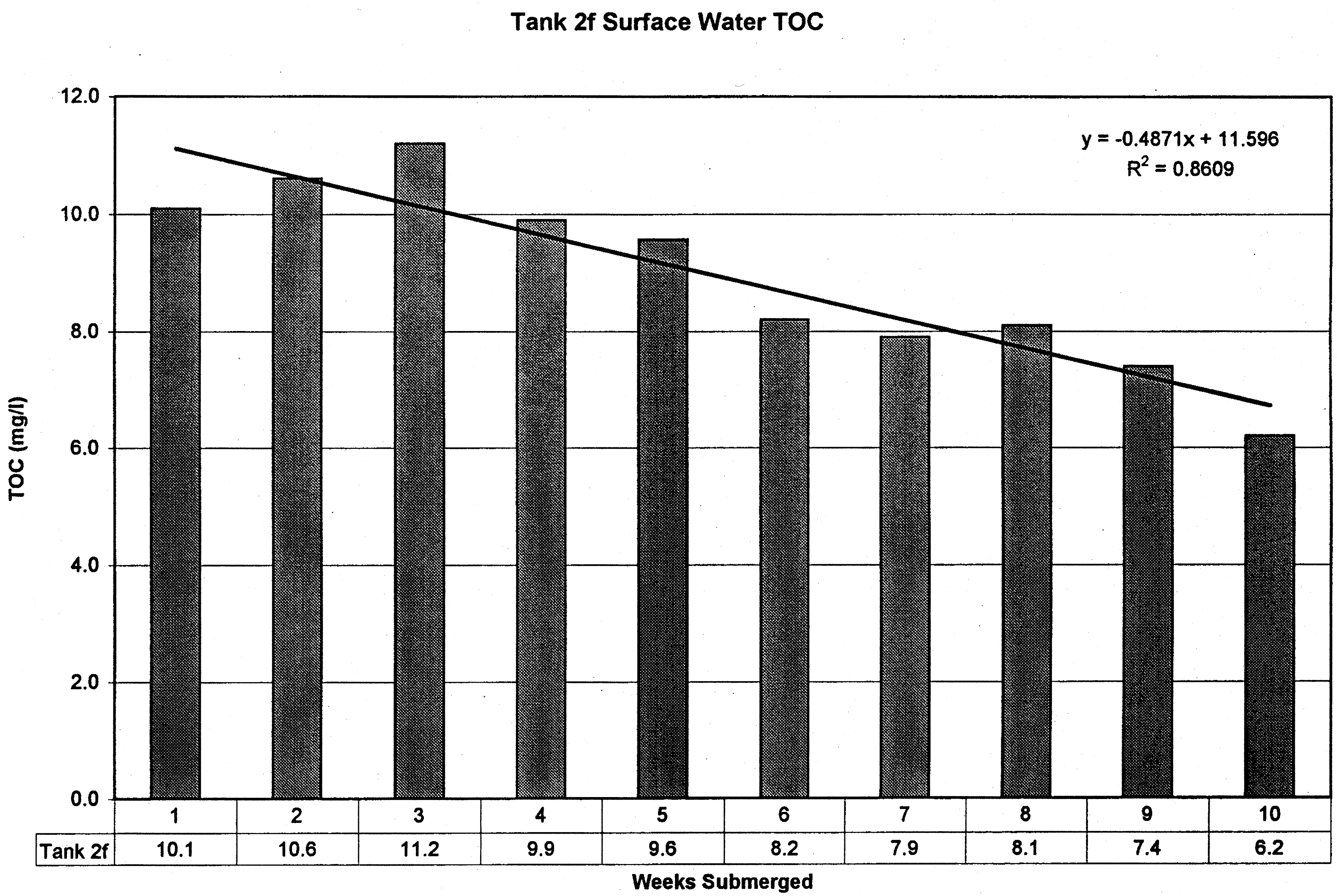
Weeks Submerged

Tank 1 Surface Water TOC



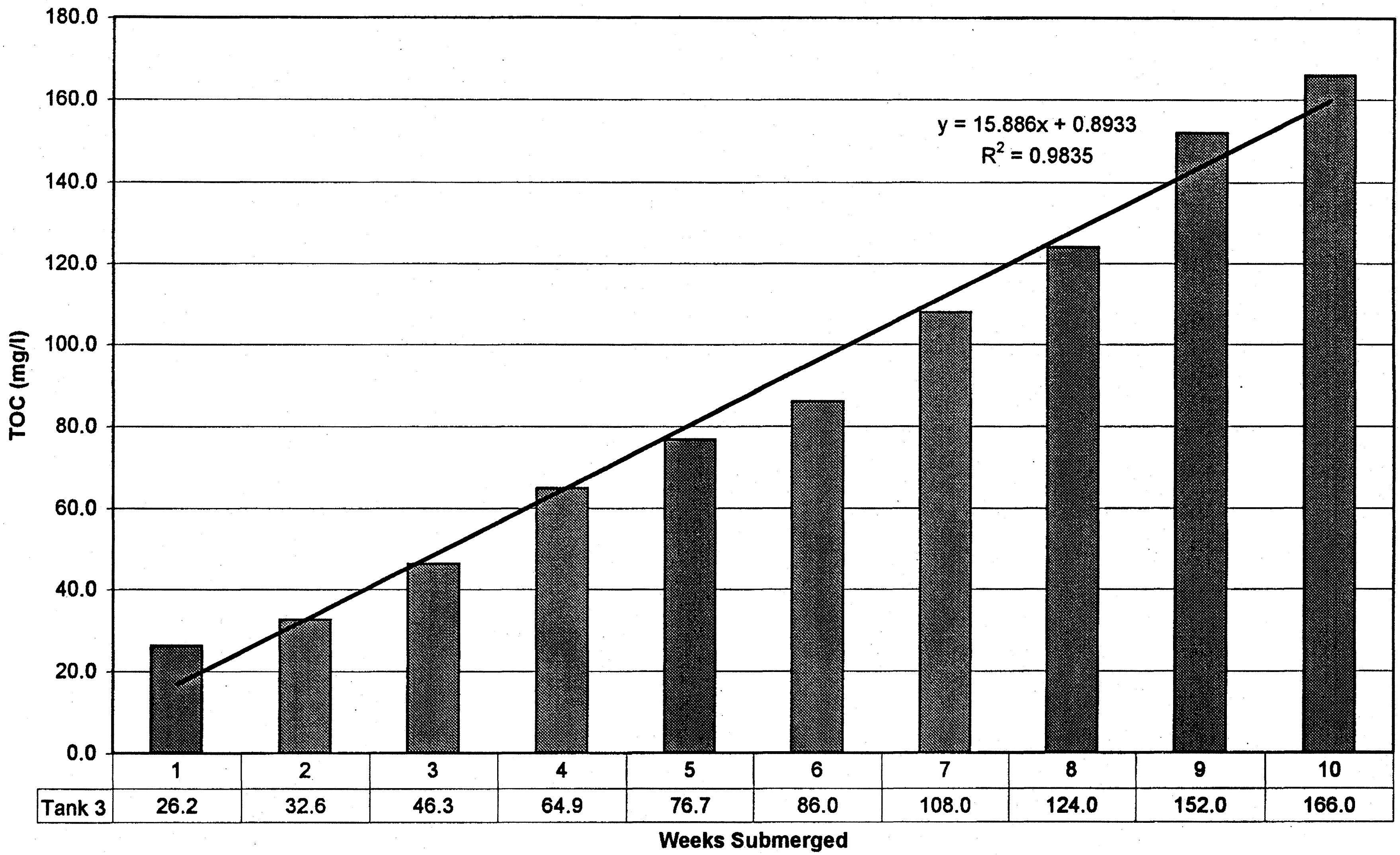
	1	2	3	4	5	6	7	8	9	10
Tank 1	11.4	11.4	15.7	21.5	24.7	26.6	31.3	30.8	36.6	38.0

Weeks Submerged

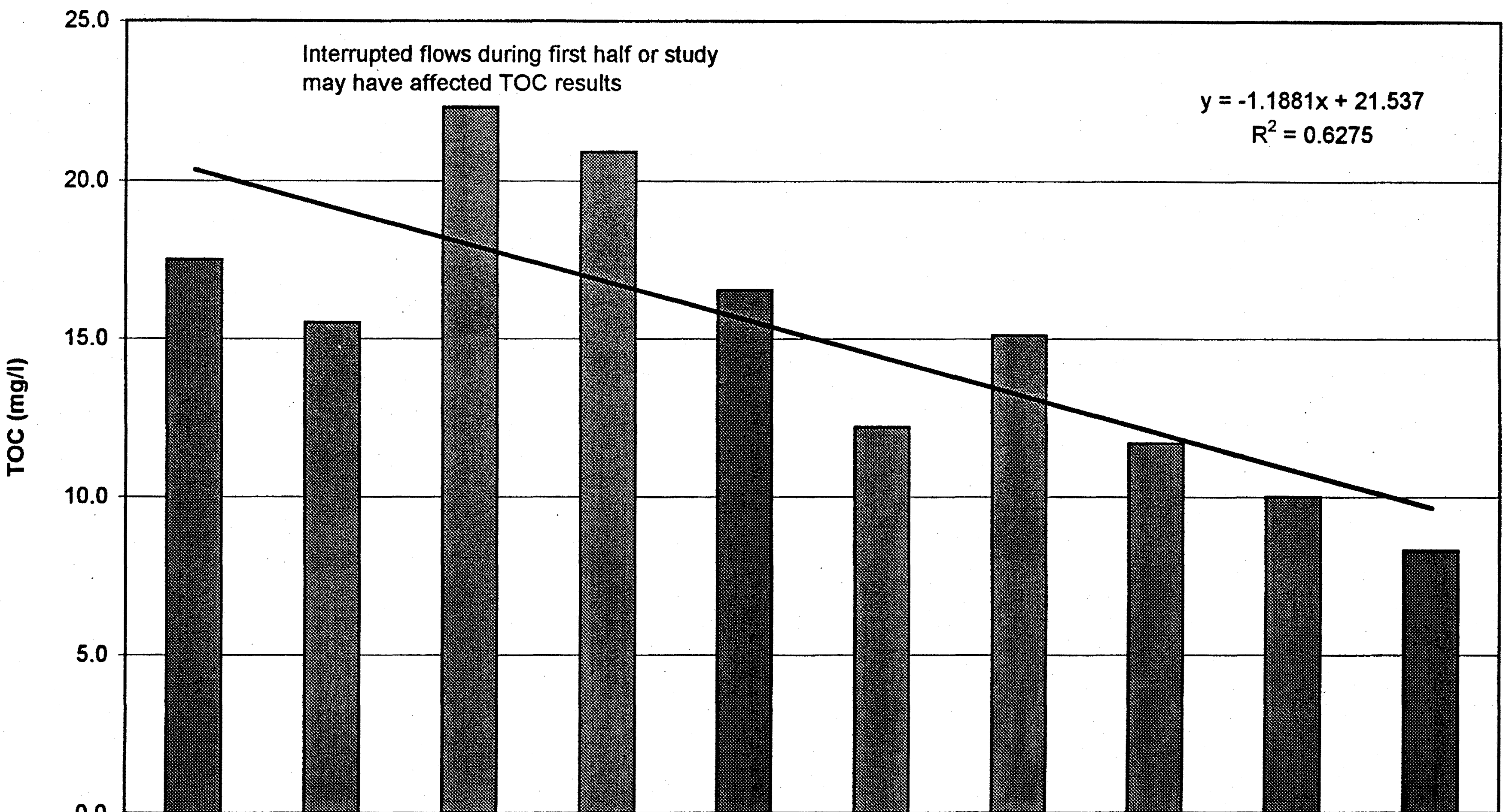


	1	2	3	4	5	6	7	8	9	10
Tank 2f	10.1	10.6	11.2	9.9	9.6	8.2	7.9	8.1	7.4	6.2

Tank 3 Surface Water TOC



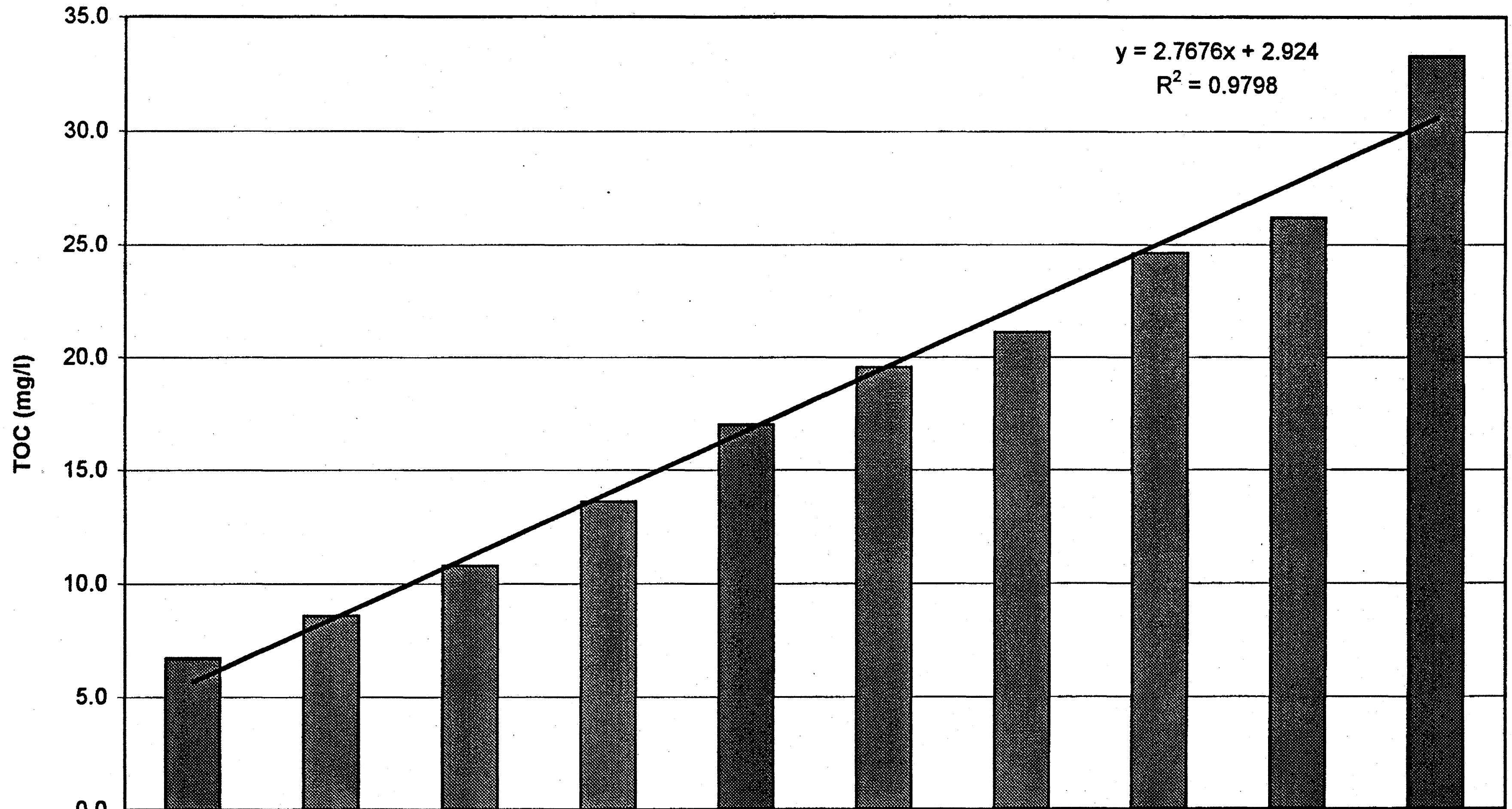
Tank 4f Surface Water TOC



	1	2	3	4	5	6	7	8	9	10
Tank 4f	17.5	15.5	22.3	20.9	16.5	12.2	15.1	11.7	10.0	8.3

Weeks Submerged

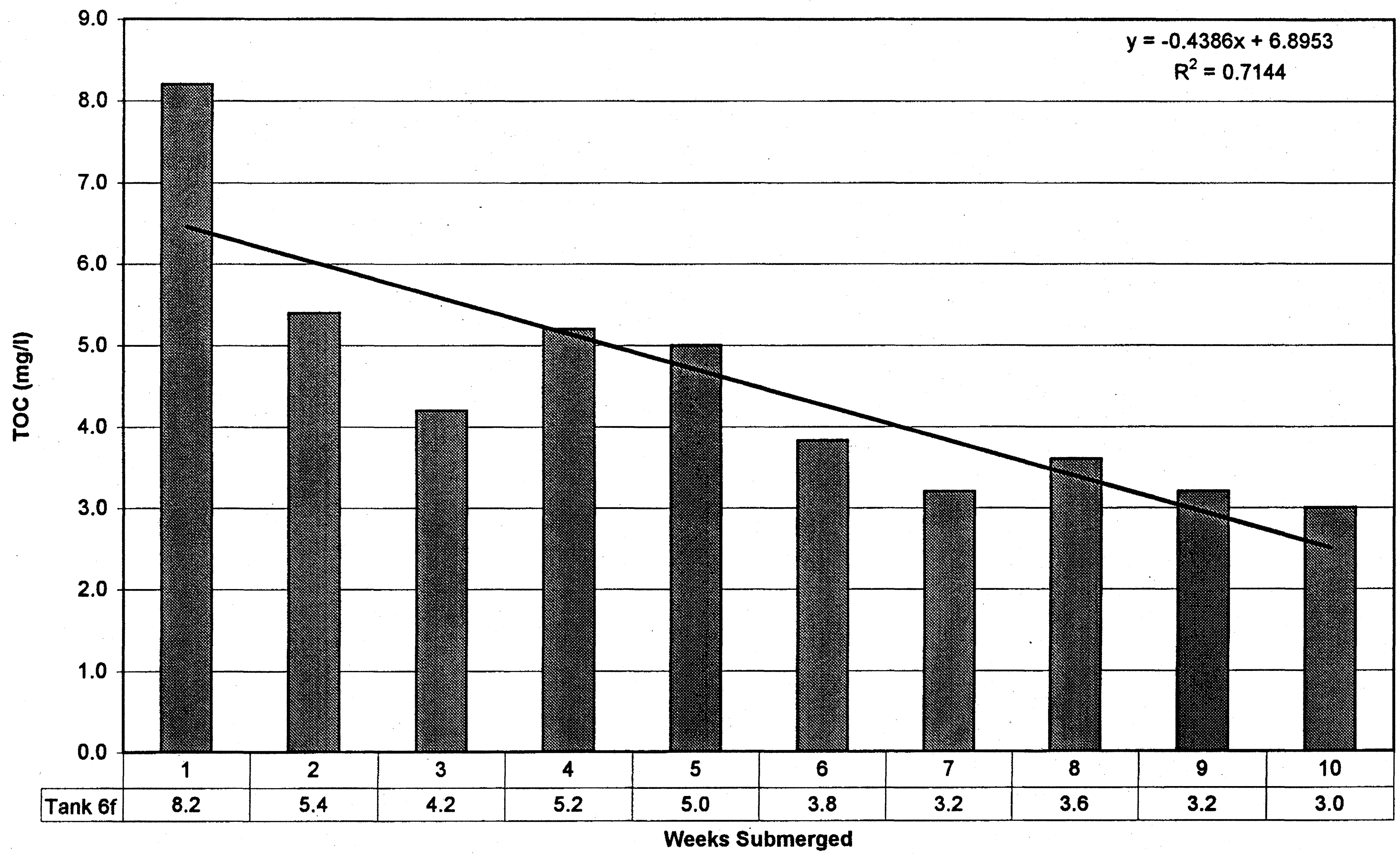
Tank 5 Surface Water TOC

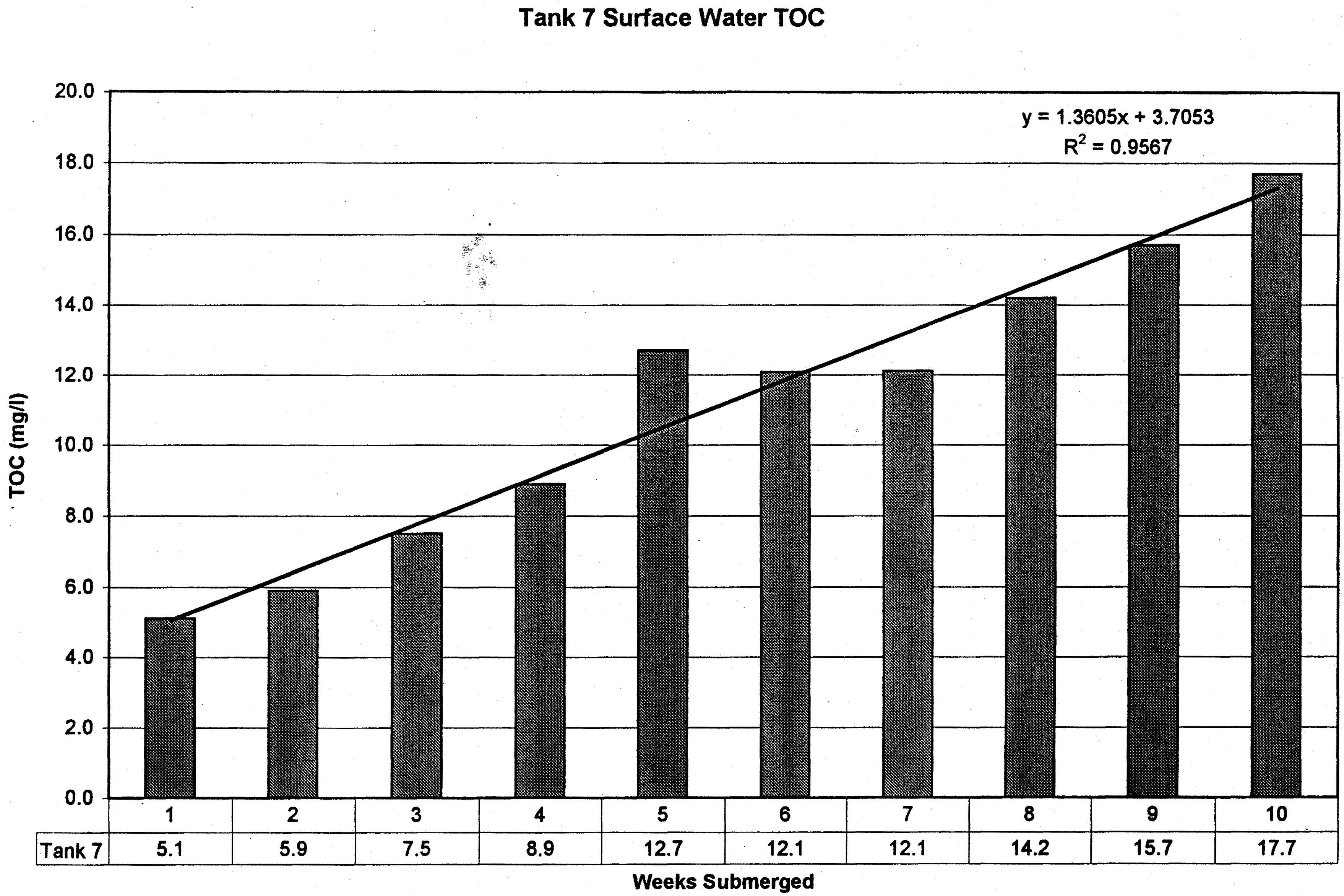


	1	2	3	4	5	6	7	8	9	10
Tank 5	6.7	8.6	10.8	13.6	17.0	19.6	21.1	24.6	26.2	33.3

Weeks Submerged

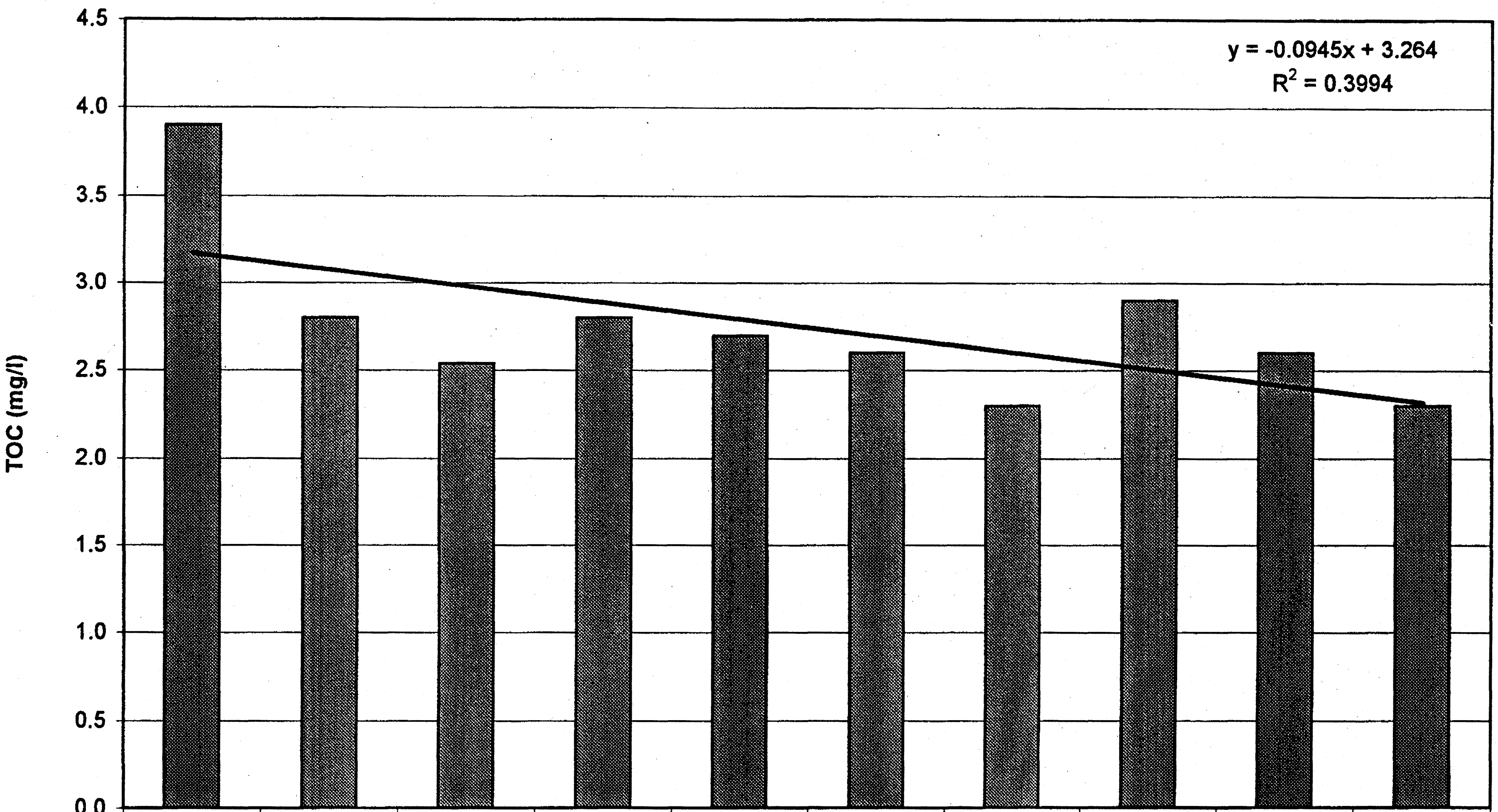
Tank 6f Surface Water TOC





	1	2	3	4	5	6	7	8	9	10
Tank 7	5.1	5.9	7.5	8.9	12.7	12.1	12.1	14.2	15.7	17.7

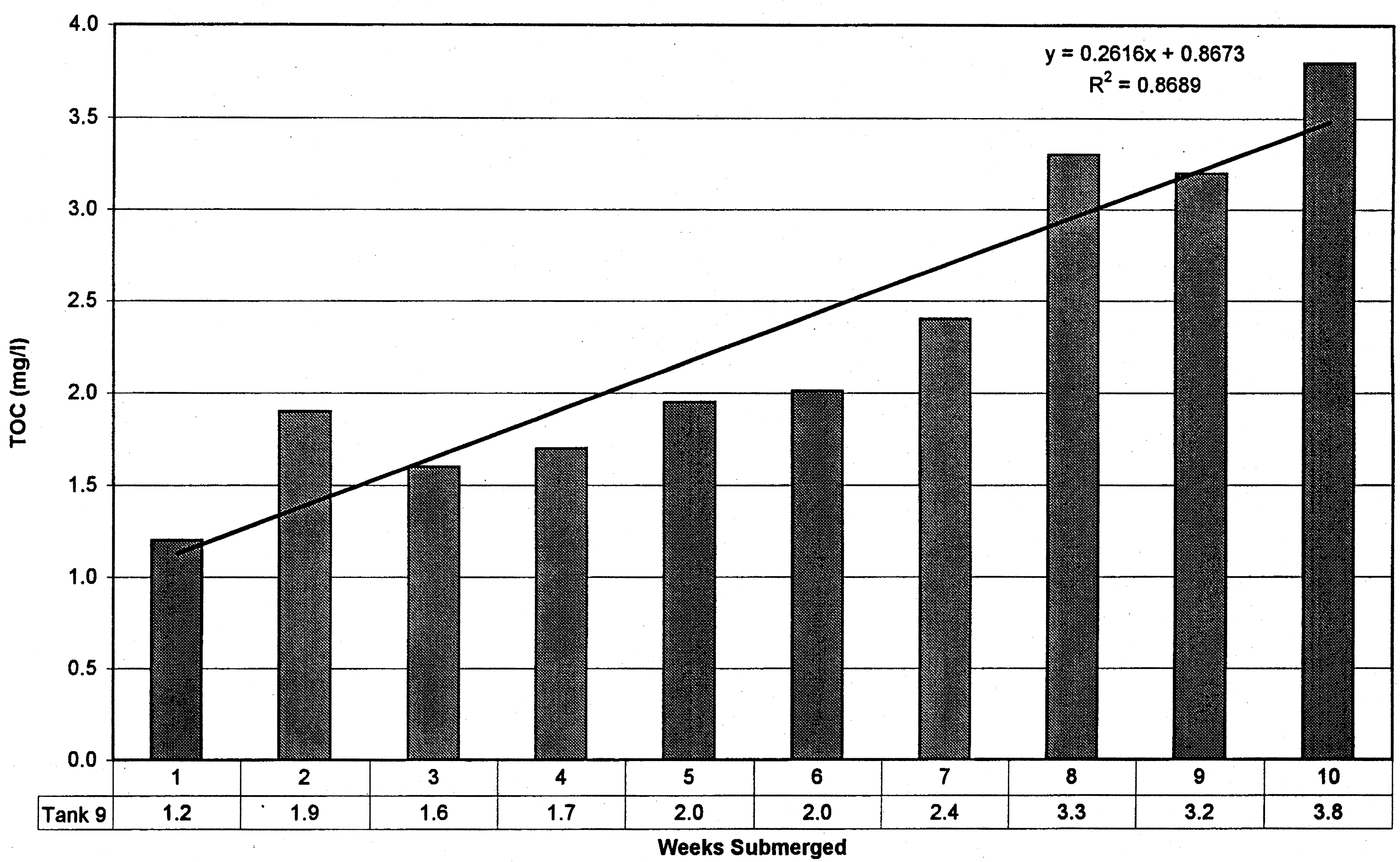
Tank 8f Surface Water TOC



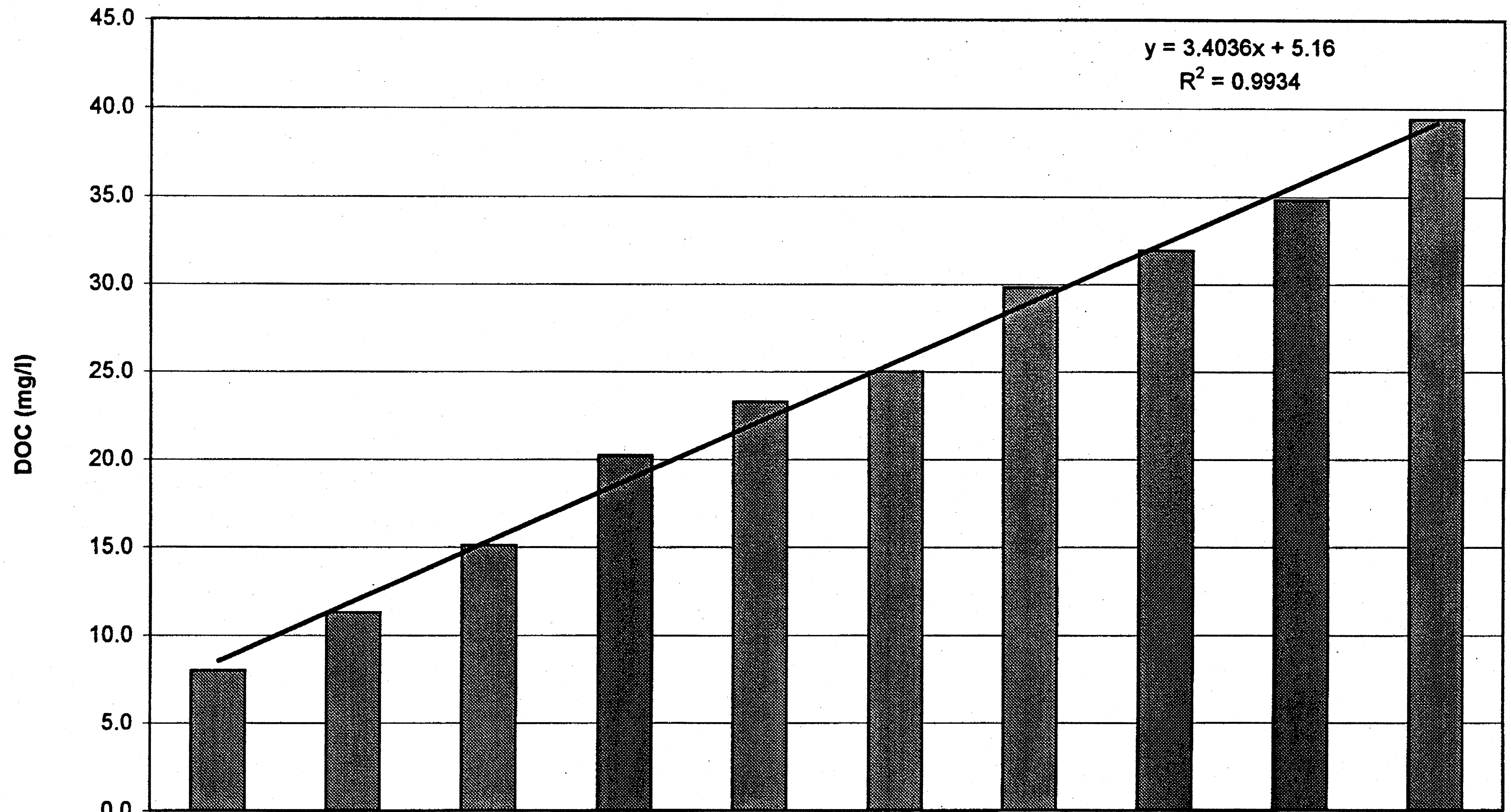
	1	2	3	4	5	6	7	8	9	10
Tank 8f	3.9	2.8	2.5	2.8	2.7	2.6	2.3	2.9	2.6	2.3

Weeks Submerged

Tank 9 Surface Water TOC

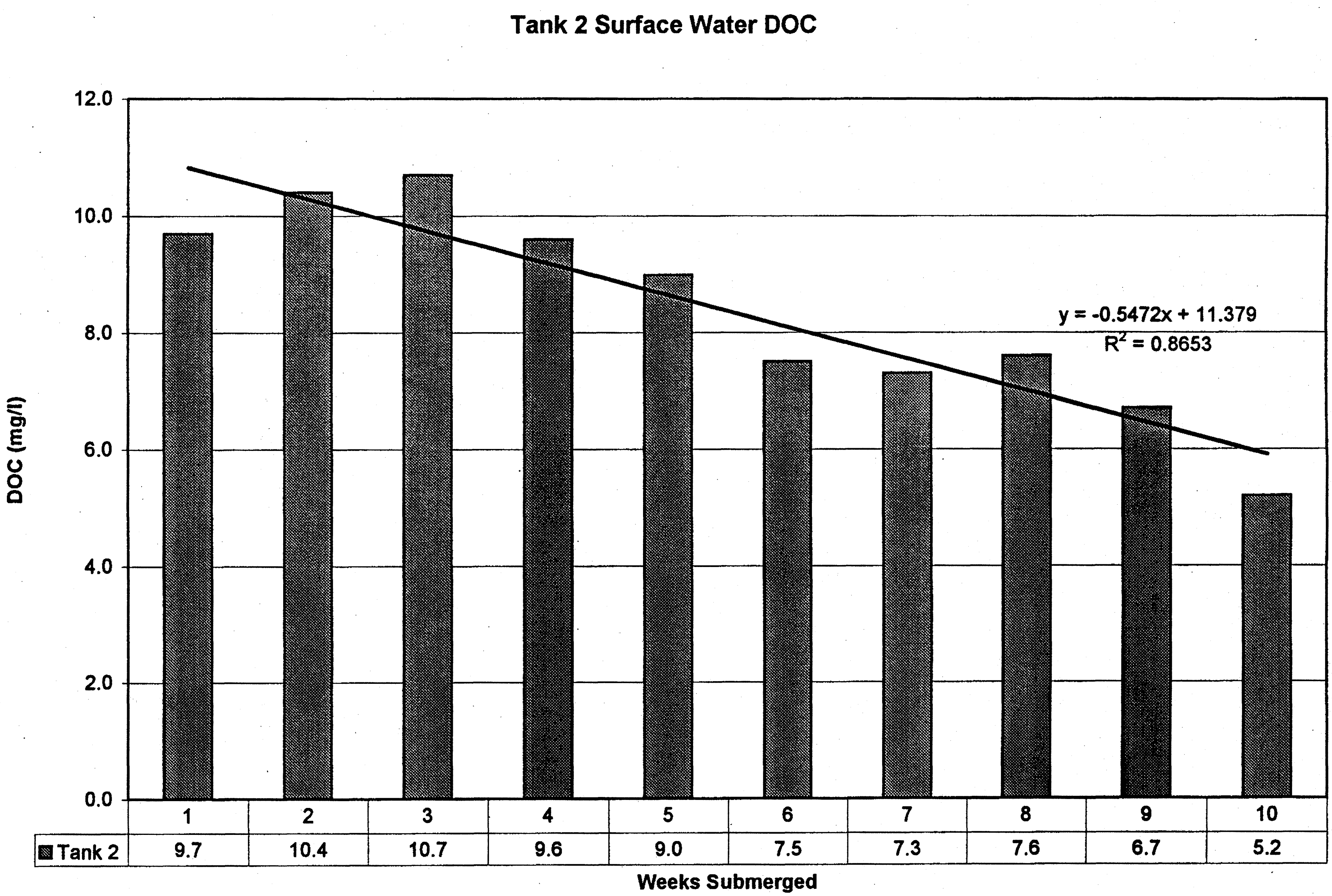


Tank 1 Surface Water DOC



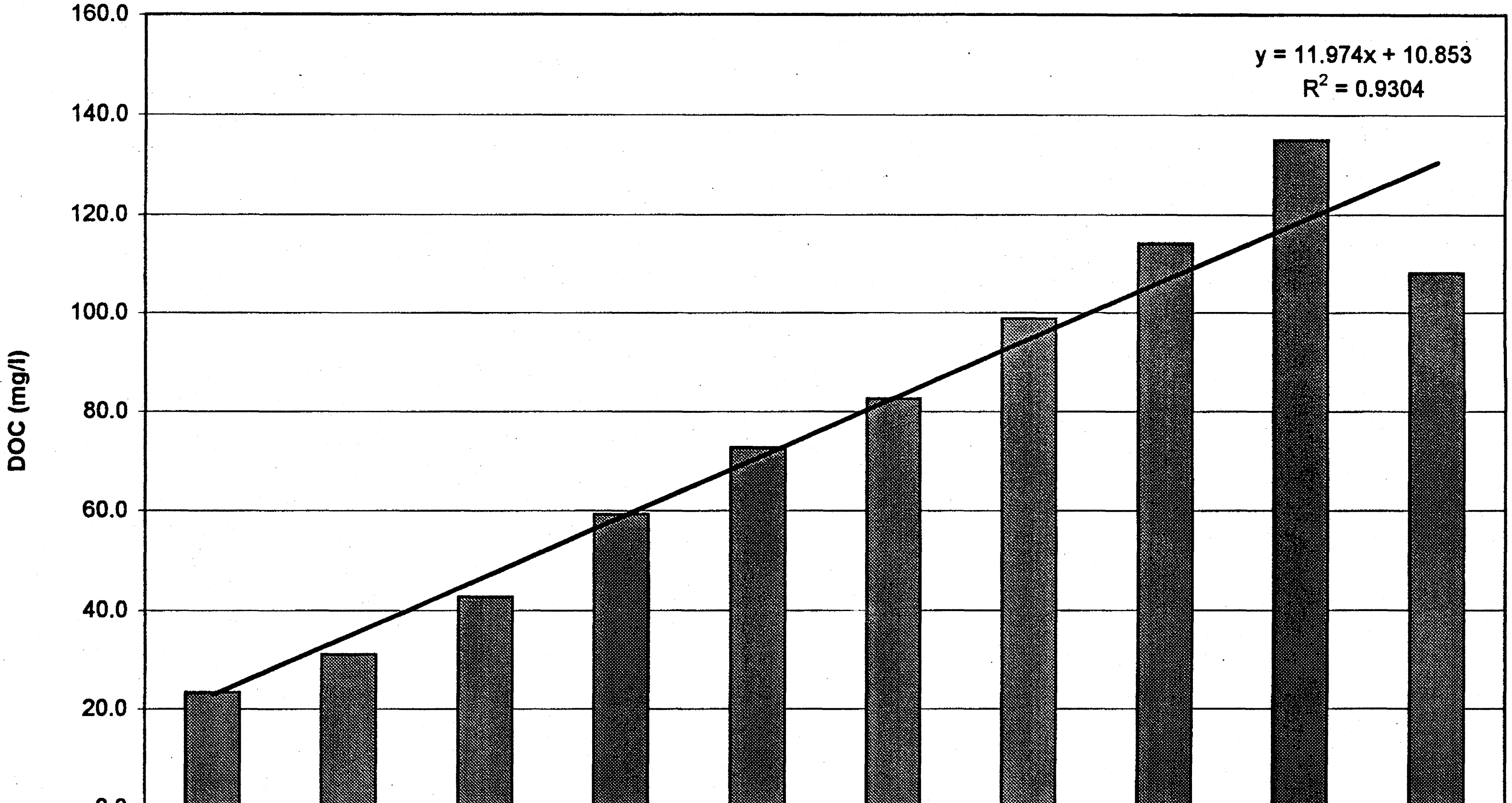
	1	2	3	4	5	6	7	8	9	10
Tank 1	8.0	11.3	15.1	20.2	23.3	25.0	29.8	31.9	34.8	39.4

Weeks Submerged



Tank 2 Surface Water DOC
DOC (mg/l)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
y = -0.5472x + 11.379
R² = 0.8653
1
2
3
4
5
6
7
8
9
10
Tank 2
9.7
10.4
10.7
9.6
9.0
7.5
7.3
7.6
6.7
5.2
Weeks Submerged

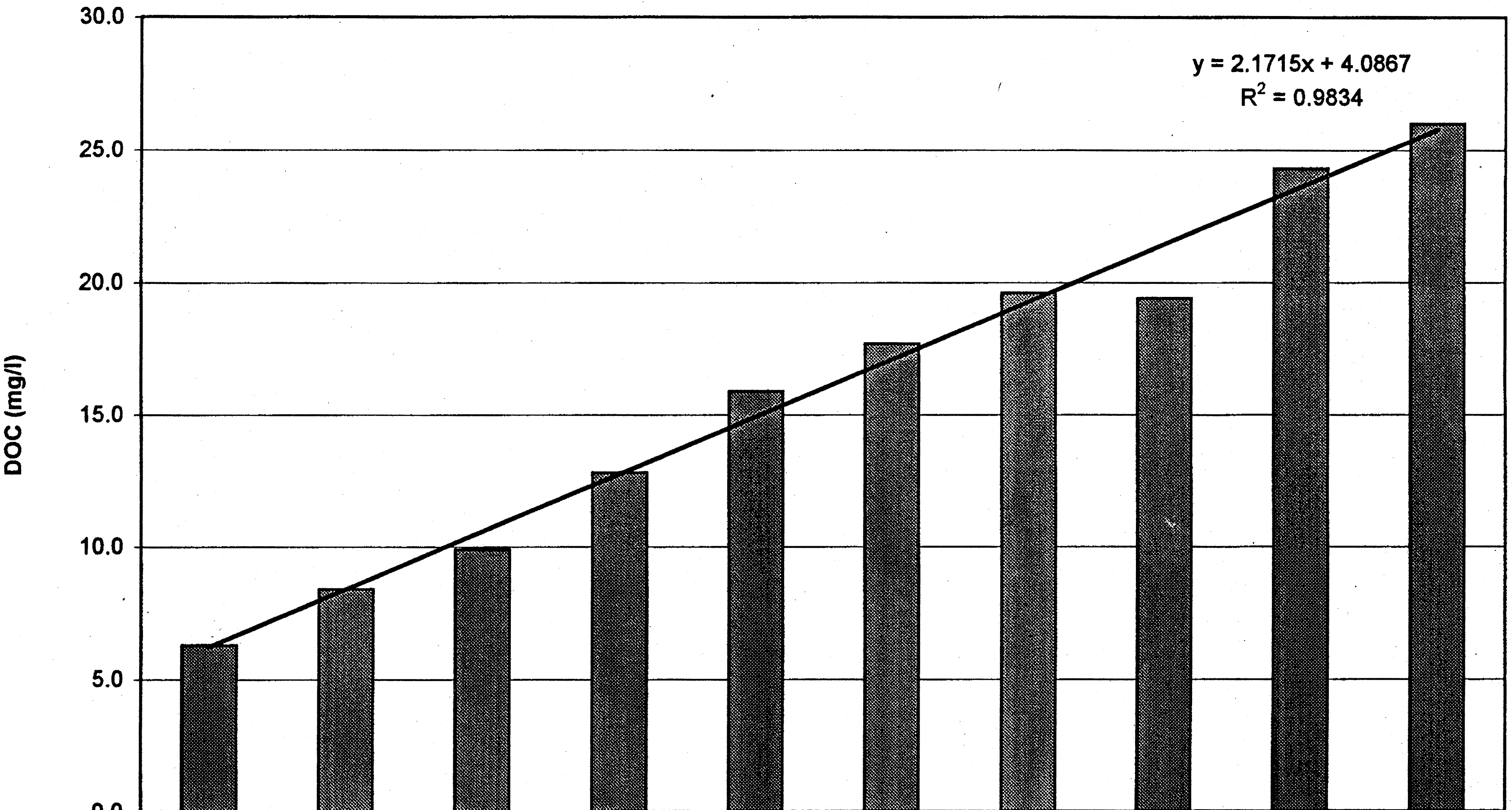
Tank 3 Surface Water DOC



	1	2	3	4	5	6	7	8	9	10
Tank 1	23.3	31.0	42.6	59.2	72.7	82.6	98.7	114.0	135.0	108.0

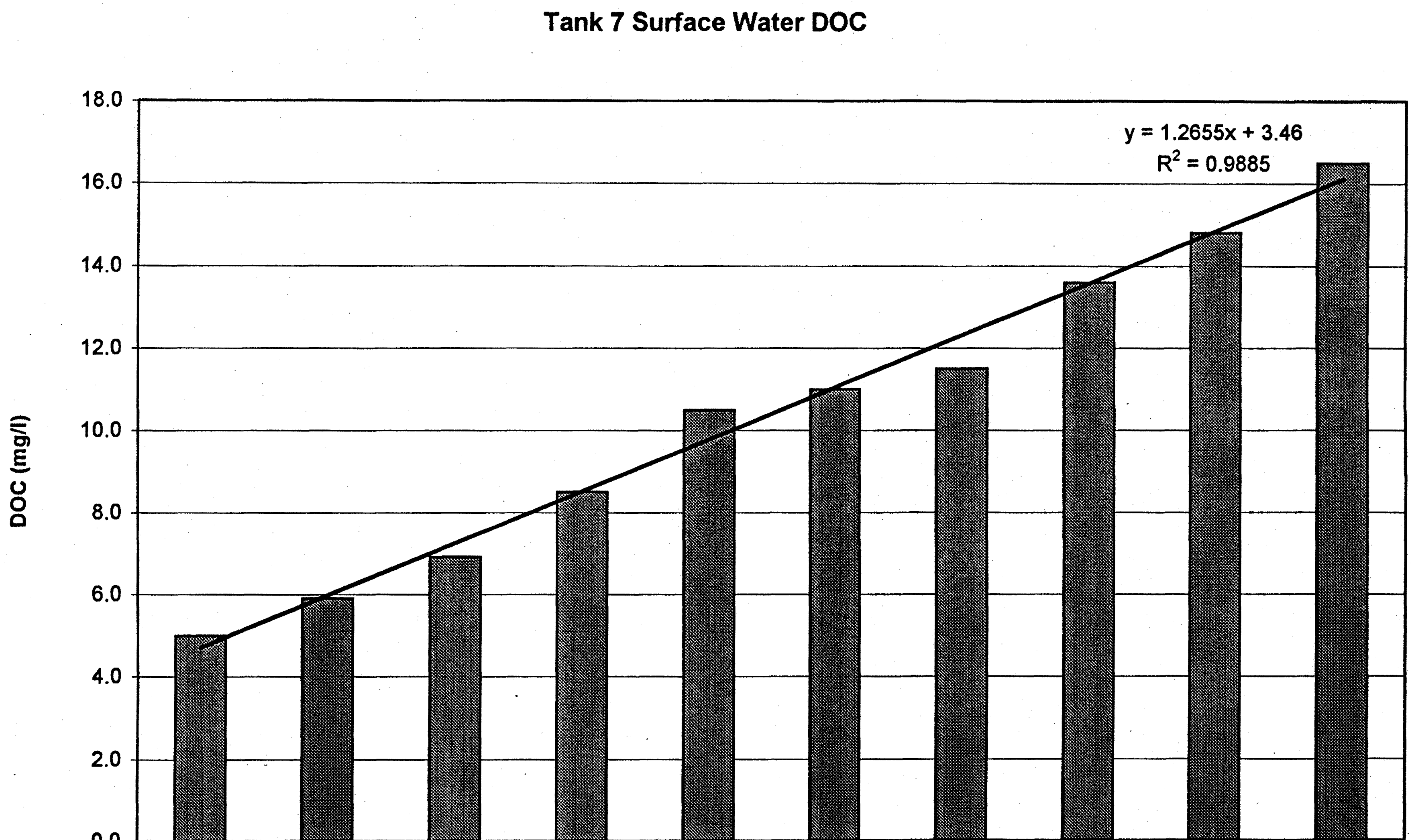
Weeks Submerged

Tank 5 Surface Water DOC



	1	2	3	4	5	6	7	8	9	10
Tank 5	6.3	8.4	9.9	12.8	15.9	17.7	19.6	19.4	24.3	26.0

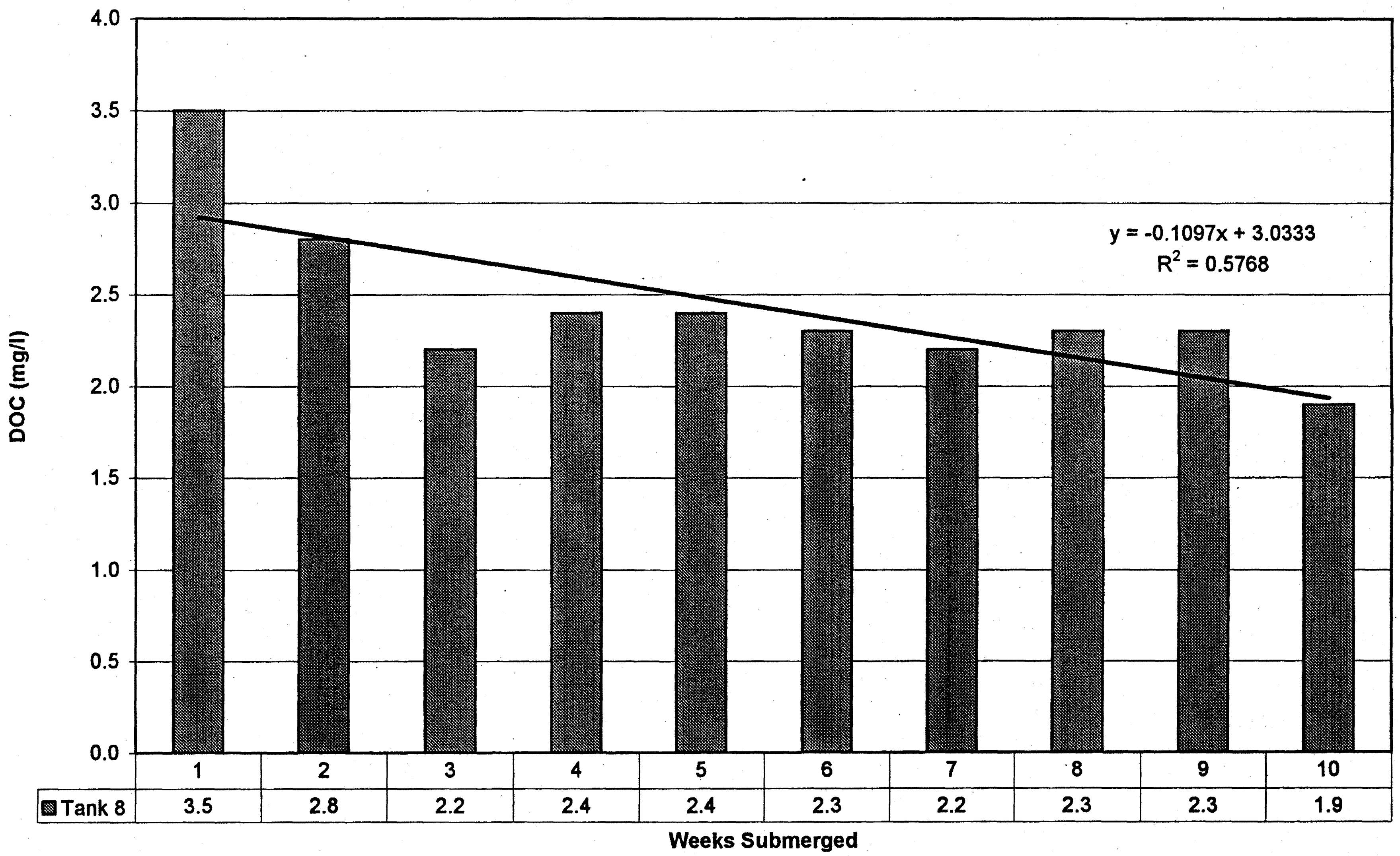
Weeks Submerged

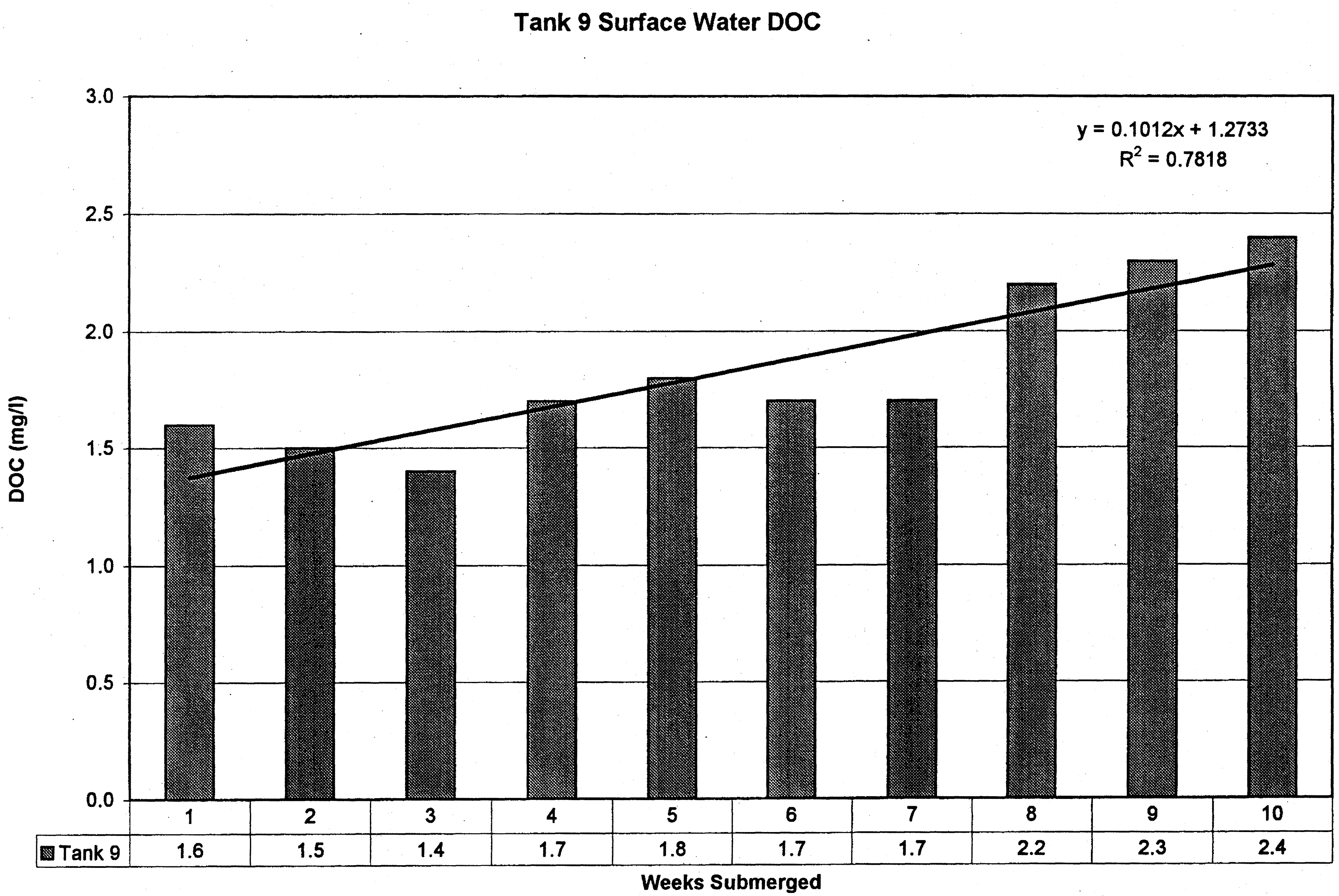


	1	2	3	4	5	6	7	8	9	10
Tank 7	5.0	5.9	6.9	8.5	10.5	11.0	11.5	13.6	14.8	16.5

Weeks Submerged

Tank 8 Surface Water DOC





	1	2	3	4	5	6	7	8	9	10
Tank 9	1.6	1.5	1.4	1.7	1.8	1.7	1.7	2.2	2.3	2.4